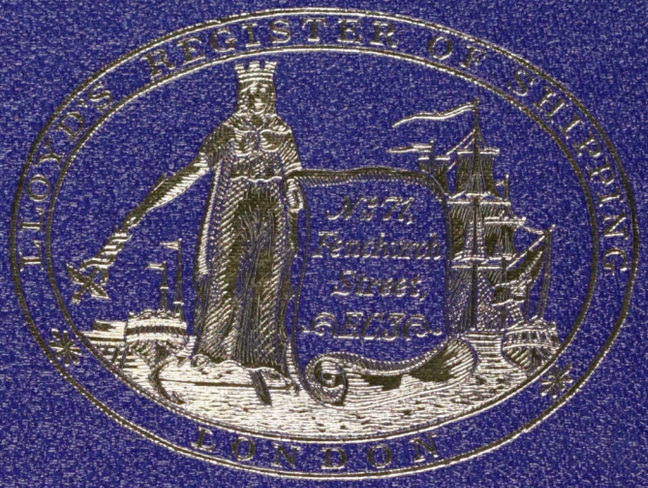


RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

1962

NOT TO BE REMOVED



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STEEL SHIPS, including General Rules and Regulations; Classification and Periodical Survey Regulations, and Rules for Construction of Steel Ships and Machinery; Boilers and other Pressure Vessels; Electric Propelling Machinery and Electrical Equipment; Pumping and Piping; Fire Extinguishing Arrangements; Machinery Spare Gear; Refrigerating Machinery and Appliances; and Quality and Testing of Materials. A Metric Edition is also published as well as editions in French, Spanish and German.

EXTRACTS FROM THE RULES FOR STEEL SHIPS:—

No. 1.—Classification Regulations and Periodical Survey Regulations

No. 2.—Classification and Periodical Survey Regulations; Pumping and Piping; Fire Extinguishing Arrangements; Steam and Internal Combustion Machinery; Boilers and other Pressure Vessels; Quality and Testing of Materials

No. 3.—Construction of Steam and Internal Combustion Machinery, and Quality and Testing of Materials

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Comprising lists (1) in alphabetical order of Firms, (2) in alphabetical order of name (if any) of anchors, together with descriptive sketches. Revised and brought up to date, 1945.

TERMS OF SUBSCRIPTION FOR THE REGISTER BOOKS AND PRICES OF OTHER PUBLICATIONS UPON APPLICATION TO THE MANAGER, LLOYD'S REGISTER PRINTING HOUSE, MANOR ROYAL, CRAWLEY, SUSSEX, ENGLAND.

LLOYD'S REGISTER OF SHIPPING

TECHNICAL COMMITTEE

FOUNDED 1760

RULES AND REGULATIONS FOR THE CONSTRUCTION AND CLASSIFICATION OF STEEL SHIPS

1962

71, FENCHURCH STREET, LONDON, E.C.3

Telephone: ROYal 9166 *Telegrams: Committee, London, Telex* *Telex No.: 24305*

401†

CHANGES EMBODIED IN PRESENT EDITION OF THE RULES

Additions and amendments which have been adopted by the Committee since the previous (1961) edition of the Rules will be found in the following Chapters:

Chapter B — CLASSIFICATION REGULATIONS

Section 8. Para. 805 has been amended.

Chapter D — STEEL SHIPS

Definitions

Section 2. A new paragraph (208) has been added.

Double Bottoms

Section 5. A new paragraph (526) has been added.

Hatchways and Deck Openings

Section 23. Para. 2325 has been amended.

Protection for Steelwork

Section 30. Paras. 3001 and 3002 have been amended.

Welded Construction

Section 31. Para. 3114 has been amended.

Table 28 Note 3(b) has been amended.

Table 36 Note 4 has been amended.

Table 43 Note 6 has been amended.

Tables 52G and **52H** have been revised.

OIL TANKERS

General

Section 40. A new paragraph (4015) has been added.

PROVISIONAL REQUIREMENTS FOR THE CARRIAGE OF LIQUEFIED PETROLEUM GASES AT OR NEAR ATMOSPHERIC PRESSURE

A new Section 70 has been added.

Chapter E — PUMPING AND PIPING

Plans

Section 1. Para. 101 has been amended.

Bilge and Ballast

Section 2. This Section has been generally revised.

Oil Fuel and Cargo Oils having a Flash Point above 150° F.

Sections 3. A new paragraph (302) has been inserted.

Paras. 313 and 315 have been amended.

New paragraphs (320, 321 and 323) have been inserted.

Paras. 340 and 345 have been amended.

Air, Overflow and Sounding Pipes

Section 4. Paras. 406, 413 and 421 have been amended.

Pressure Pipes

Section 5. Para. 520 has been amended.

Steam Pipe Ranges

Section 6. Para. 605 has been amended.

Engine Cooling Water Systems

Section 8. Para. 801 has been amended.

Lubricating Oil Systems

Section 9. Para. 901 has been amended.

Piping for Petrol and Paraffin Engines

This Section, having no present day application, has been deleted.

Petroleum and Other Liquid Cargoes having a Flash Point below 150° F.

Section 11. Paras. 1114 and 1115 have been amended.

Chapter G — CONDITIONS FOR SURVEY OF MACHINERY DURING CONSTRUCTION

Section 1. Paras. 103 and 104 have been amended.
A new paragraph (110) has been added.

Chapter H — MAIN AND AUXILIARY ENGINES AND GEARING

Turbines and Propelling Motors

Section 3. Para. 301 has been amended.

General Requirements for Steam Reciprocating Engines and Steam and Gas Turbines

Section 4. This Section has been revised and enlarged under the above heading.

General Requirements for Heavy Oil Engines and Starting Air Compressors

Section 7. Paras. 705, 707, 710 and 711 have been amended.
New paragraphs (723 and 724) have been inserted.

Chapter J — BOILERS AND OTHER PRESSURE VESSELS

Boiler Mountings and Fittings

Section 4. Para. 425 has been amended.

Requirements for Class I Fusion Welding

Section 19. Paras. 1920 and 1925 have been amended.

Requirements for Class 2 Fusion Welding

Section 20. Para. 2010 has been amended.

The Rules for "ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY" have been completely revised and are now included in Chapter M.

Chapter N — REFRIGERATED CARGO INSTALLATIONS

General

Section 1. A new Paragraph (105) has been added.

Refrigerating Plant

Section 3. Paras. 314, 337 and 359 have been amended.

Chapter P — QUALITY AND TESTING OF MATERIALS

Steel for Boilers, Pressure Vessels and Welded Machinery Structures

Section 3. Para. 311 has been amended.

Steel Castings

Section 5. Paras. 502, 508 and 515 have been amended.
New requirements, dealing specifically with Turbine Castings, have been added to this Section.

Ingot Steel Forgings

Section 6. This Section has been enlarged to include new requirements dealing specifically with Turbine Forgings.

The above additions and amendments were promulgated in Notice 2182, in Notice 2186 and in Notice 2193. A number of alterations of a minor or editorial nature have also been made.

W. J. FERGUSON,
Secretary and Chief Executive.

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Chapter A

GENERAL RULES AND REGULATIONS OF LLOYD'S REGISTER OF SHIPPING

Section 1

THIS Society, founded in 1760 and reconstituted in 1834, was established for the purpose of obtaining for the use of Merchants, Shipowners, and Underwriters, a faithful and accurate Classification of Mercantile Shipping, and for the government of which the following Rules and Regulations have been from time to time adopted.

Section 2

The superintendence of the affairs of the Society to be under the direction of a General Committee composed of Merchants, Shipowners, and Underwriters (twenty-four elected in London, namely, nine by the Committee of Lloyd's, twelve by the Committee of the London General Shipowners' Society, and three by the Committee of the Institute of London Underwriters, and thirty-seven at the principal Outports), and the following, namely:— Shipbuilders and/or Engineers, not exceeding ten, who may be elected by the General Committee; additional Members not exceeding twelve, who may be elected by the General Committee; past Chairmen, Deputy-Chairmen and Treasurers, and Deputy-Chairmen and Chairmen of the Sub-Committees of Classification of the Society, who may be elected by the General Committee, and the following *ex-officio* Members, namely:— The Chairman, or, in his absence, the Deputy-Chairman, of the Corporation of Lloyd's; the Chairman, or, in his absence, the Deputy-Chairman, of the London General Shipowners' Society; the Chairman, or, in his absence, the Deputy-Chairman, of the Institute of London Underwriters, and the Chairman of each National Committee established abroad.

The General Committee is further empowered to elect as Honorary Members of the General Committee such persons of distinction and eminence as the General Committee shall from time to time think fit.

Any Member (except an *ex-officio* Member, or a Member elected by the General Committee) who fails to attend any meetings of the General Committee for a period of six consecutive months, without leave of absence, shall cease to be a Member, and his place shall be filled up in the usual way.

NOTE.—Official intimation to be given in June of each year whether the Chairman or Deputy-Chairman of the Corporation of Lloyd's, the Chairman or Deputy-Chairman of the London General Shipowners' Society, and the Chairman or Deputy-Chairman of the Institute of London Underwriters, are to be the *ex-officio* Members for the ensuing twelve months.

Section 3

The General Committee reserve the right of varying or withdrawing the representation of Outports, and of Shipbuilders and Engineers; also the representation of Shipbuilders, Engineers, Steel Makers, and Forgemasters on the Technical Committee hereinafter mentioned, as well as the mode of election of Members.

Section 4

1. Seven of the Members elected in London, namely, three representatives of Lloyd's, three representatives of the London General Shipowners' Society, and one representative of the Institute of London Underwriters, to retire annually by rotation, but to be eligible for re-election. The vacancies so arising to be filled by the election of three representatives by the Committee of Lloyd's, three representatives by the Committee of the London General Shipowners' Society, and one representative by the Committee of the Institute of London Underwriters.

2. Of the Members elected at the Outports twenty-one to retire at the end of four years, and seven of the Members elected at Liverpool and the nine Members elected at Glasgow to retire annually. The retiring Members are eligible for re-election.

3. All Members elected by the General Committee are to retire at the end of four years, and are to be eligible for re-election.

Section 5

The Committee to appoint Sub-Committees of Classification, to be so regulated that each Member of the General Committee may, in rotation, take his turn of duty thereon throughout the year.

Section 6

The Committee to appoint from their own body, annually, a Chairman and two Deputy-Chairmen; one being designated Deputy-Chairman and Treasurer and the other Deputy-Chairman and Chairman of the Sub-Committees of Classification.

Section 7

The Secretary, Clerks, and Servants of the Society, and the Surveyors, to be appointed by and be under the direction of the General Committee.

Section 8

Special meetings to be convened by order of the Chairman, or one of the Deputy-Chairmen, or on the requisition of any three Members.

Section 9

All elections and appointments to be made by ballot, excepting when, in the election of Chairman or one of the Deputy-Chairmen, only one person is nominated for each office.

Section 10

No Member of the Committee to be permitted to be present on the decision of the classification of any ship of which he is the owner, or wherein he is directly, or indirectly, interested.

Section 11

1. The Committee to be empowered to make such By-Laws for their own government and proceedings as they may deem requisite, not being inconsistent with the original Rules and Regulations under which the Society was established; but no new Rule or By-Law to be introduced or any Rule or By-Law altered, without special notice being given for that purpose at the meeting of the Committee next preceding that at which such motion is intended to be made; such notice to be inserted in the summons convening the meeting.

2. No new Rule, or alteration in any existing Rule materially affecting the classification of ships, to be applied compulsorily to ships of which the plans have been submitted and approved before the expiration of six months after the date when the change has been adopted.

Section 12

A Register Book to be printed annually for the use of Subscribers, containing the names of the ships with other useful information, and the character assigned, where the ships are classed by the Society; also the names, etc., of ships of 100 gross registered tons and upwards which are not classed with the Society.

The terms of subscription to be such annual sum or sums as may from time to time be determined by the General Committee.

Section 13

TECHNICAL COMMITTEE

1. The Technical Committee to be constituted as follows:—

Ex-officio—	Ship-owners	Under-writers	Ship-builders	Engineers	Others	TOTAL
The Chairman of Lloyd's Register	1	–	–	–	–	1
The Deputy-Chairman and Treasurer of Lloyd's Register	–	1	–	–	–	1
The Deputy-Chairman and Chairman of the Sub-Committees of Classification	1	–	–	–	–	1
Nominated by—						
The General Committee of Lloyd's Register	5	3	2	2	–	12
Institution of Naval Architects	–	–	1	1	–	2
North-East Coast Institution of Engineers and Shipbuilders	–	–	1	1	–	2
The Institution of Engineers and Shipbuilders in Scotland	–	–	1	1	–	2
The Shipbuilding Conference	–	–	5	–	–	5
The National Association of Marine Enginebuilders ...	–	–	–	3	–	3
The Institute of Marine Engineers	–	–	–	2	–	2
The Society of Consulting Marine Engineers and Ship Surveyors	–	–	–	1	–	1
Dry Dock Owners' and Repairers' Central Council ...	–	–	–	–	2	2
The Iron and Steel Institute	–	–	–	–	1	1
British Iron and Steel Federation	–	–	–	–	1	1
National Forgemasters' Association	–	–	–	–	1	1
The Honourable Company of Master Mariners... ...	–	–	–	–	1	1
The Institution of Electrical Engineers	–	–	–	–	1	1
The British Electrical and Allied Manufacturers' Association	–	–	–	–	1	1
National Committees of Lloyd's Register abroad ...	–	–	–	–	11	11
The Technical Committee...	3	–	2	2	–	7
„ „ „ (from other countries abroad)	–	–	–	–	8	8
	10	4	12	13	27	66

The above nominations to be subject to confirmation by the General Committee.

In addition to the foregoing, further persons may, with the consent of the General Committee, be co-opted to serve on the Technical Committee.

2. The function of the Technical Committee is to consider any technical problems connected with the Society's business and any proposed alterations in the existing Rules, or to frame new Rules, for the classification, survey and building of ships (hulls and machinery).

3. The term of office of all Members to be four years, one-fourth retiring each year, the Members so retiring to be eligible for renomination for a second term. Unless specially so authorised by the General Committee, no Member, other than the Chairman and/or Vice-Chairmen, who has served for two periods of four years to be eligible for renomination for a third term until after the expiration of at least one year. In the event of any vacancy occurring before the expiration of a term of four years a representative to be nominated to fill the vacancy for the unexpired portion of the term.

4. With the exception of any Superintendents nominated by the Technical Committee, only those who are actually partners in firms, or directors or managers of joint stock companies, or of similar status, to be eligible for membership.

5. The Technical Committee to appoint from their own body, biennially, a Chairman, who must be a Member of the General Committee, and, if desired, two Vice-Chairmen, who need not be Members of the General Committee. The same Members not to be eligible to hold office for more than four years in succession, unless on the occasion of the third election a ballot—to be taken whether there be any other candidates or not—shows a majority in their favour of at least three-fourths of the Members present. The appointment of Chairman and of Vice-Chairmen to be confirmed by the General Committee.

6. Meetings of the Technical Committee to be convened as often and at such times and places as may appear necessary, but there shall be at least three meetings in each year.

7. Members desiring to propose alterations in, or additions to, the Rules for the classification, survey or building of ships (hull and machinery) shall give notice of all such proposals in writing to the Secretary.

Every meeting to be convened by notice from the Secretary, if possible one month before the date of meeting; and the Secretary to send each Member an agenda paper as soon as possible thereafter.

8. Any proposals of the Technical Committee involving any amendment of, or addition to, the Rules for the classification, survey or building of ships (hull and machinery) to be reported to the General Committee, who will refer them to a special meeting of the General Committee, as required by Section 11 of this Chapter.

9. The Technical Committee to be empowered:—

(i) to draw up, if they so desire, By-Laws for governing procedure at meetings;

(ii) to appoint Panels of the Committee;

(iii) to co-opt to the main Committee, or to such Panels, representatives of any organisation or industry or private individuals for the purpose of considering any particular problem.

10. The General Committee reserve to themselves the right of varying, adding to, or rescinding, at their discretion, any or all the foregoing Regulations in this Section.

Section 14

All reports of survey are to be made by the Surveyors according to the form prescribed, and submitted for the consideration of the General Committee, or of the Sub-Committees of Classification; but the character assigned by the latter to be subject to confirmation by the General Committee.

Section 15

The reports of the Surveyors (and all documents and proceedings relating to the classification of ships) are to be carefully preserved and shall, subject to the approval, in his absolute discretion, of the Chairman, or one of the Deputy-Chairmen, be open to the inspection of the Owner and of any other person authorised in writing by the Owner.

Copies of reports will, subject to the approval of one of the Chairmen as indicated above, be supplied to Owners, or their representatives, on application.

Section 16

The Surveyors to the Society are not to be permitted (without the especial sanction of the Committee) to receive any fee, gratuity, or reward whatsoever for their own use or benefit, for any service performed by them in their capacity of Surveyors to this Society, on pain of immediate dismissal.

Section 17

While the Committees of the Society use their best endeavours to ensure that the functions of the Society are properly executed, it is to be understood that neither the Society nor any Member of any of its Committees is under any circumstances whatever to be held responsible for any inaccuracy in any report or certificate issued by the Society or its Surveyors, or in any entry in the Register Book or other publication of the Society, or for any error of judgment, default or negligence of any of its Committees or any Member thereof, or the Surveyors, or other Officers or Agents of the Society.

Section 18

The funds and accounts to be under the authority and control of the Committee.

Section 19

Fees are chargeable for all surveys held by the Society's Surveyors at ports in the United Kingdom in accordance with established scales.

For all surveys held at ports abroad fees will be chargeable according to the nature and extent of the services rendered.

Travelling expenses incurred by the Surveyors in connection with the above services are also chargeable.

Section 20

The class of a ship is liable to be withheld, or, if already granted, may be withdrawn or expunged from the Register Book, in the case of non-payment of any fees or expenses chargeable on account of such ship.

23rd March, 1961

Chapter B

CLASSIFICATION REGULATIONS

Section 1

CLASSIFICATION

General

101 Steel ships built in accordance with the Society's Rules and Regulations, or with alternative arrangements equivalent thereto (*see* B 501), will be assigned a class in the Register Book and will continue to be classed so long as they are found, upon examination at the prescribed annual and other periodical surveys, to be maintained in a fit and efficient condition and in accordance with the requirements of the Rules.

The Committee, in addition to requiring compliance with the Society's Rules, may require to be satisfied that very small ships, or ships of special type are suitable for the geographical limits of service contemplated.

Classification will be conditional upon compliance with the Society's requirements in respect of both hull and machinery (i.e., main and auxiliary engines, boilers, essential appliances, pumping arrangements and electrical equipment).

The Rules are framed on the understanding that ships will be properly loaded and handled; they do not provide for special distributions or concentrations of loading. The Committee may also require additional strengthening to be fitted in any ship which, in their opinion, may be subjected to severe stresses due to particular features in her design or when it is desired to make provision for exceptional loaded or ballasted conditions. In these cases particulars are to be submitted for consideration.

The Committee cannot assume responsibility for stability, trim, hull vibration or other technical characteristics not covered by the Rules, but they are willing to advise on these matters. They are also willing to act in respect of national and international statutory safety and other requirements for passenger and cargo ships governing arrangements not covered by the Society's Rules.

Character of Classification and Class Notation

102 Class 100A1. This class will be assigned to sea-going ships built in accordance with the Society's Rules and Regulations for the draught required.

103 Class 100A1 oil tanker. This class will be assigned to sea-going tankers intended to carry oil in bulk and built in accordance with the Society's Rules and Regulations for the draught required.

Where the scantlings and arrangements have been approved by the Committee for the carriage of oil having a flash point above 150° F., or other liquid cargoes in bulk, the class notation affixed to the character will be suitably modified to show the nature of the cargo.

104 Class 100A1 ore carrier. This class will be assigned to sea-going ships specially designed for the carriage of ore and built in accordance with the Society's Rules and Regulations for the draught required.

105 Class 100A1 trawler. This class will be assigned to all trawlers built in accordance with the Society's Rules and Regulations for the Construction of Steel Trawlers.

106 Class 100A1 tug. This class will be assigned to all sea-going tugs built in accordance with the Society's Rules and Regulations for such ships.

107 Class 100A1 for restricted service or for special purposes. This class will be assigned to sea-going ships intended to operate within specific limits or for special purposes and built in accordance with the Society's Regulations and the scantlings, arrangements and equipment specially approved by the Committee for such ships. The class notation affixed to the character in the Register Book will indicate the geographical limits of the service or the particular purpose for which the class is assigned.

108 Class A1 for restricted service. This class will be assigned to ships intended to trade only within specially sheltered waters, such as harbours, rivers or estuaries, provided the scantlings, arrangements and equipment are approved by the Committee as suitable for such service. The class notation affixed to the character will indicate the geographical limits for which the ship has been approved.

109 Special cargoes. In dry cargo ships any compartments intended for the carriage of liquid cargoes, such as vegetable or mineral oils, having a flash point above 150° F., which are in accordance with the requirements of the Rules relating thereto, will have an appropriate class notation entered in the Register Book.

Descriptive Notations

110 Ships for special duties. When a ship is designed to fulfil specific duties, a description of these duties indicating the special features incorporated in the ship may be entered in the Register Book, e.g., dredger, hopper barge.

Where the scantlings and arrangements have been approved by the Committee for cargoes of a special nature, a notation indicating the nature of such cargo may be entered in the Register Book.

Strengthening for Navigation in Ice

111 Where an ice class notation is desired, additional strengthening is to be fitted in accordance with the special requirements given in the Rules which are based on Baltic conditions. Three classes of ice strengthening are detailed in the Rules:—

Ice Class 1 strengthening is for ships intended to navigate in severe ice conditions.

Ice Class 2 strengthening is for ships intended to navigate in intermediate ice conditions.

Ice Class 3 strengthening is for ships intended to navigate in light ice conditions.

It is the responsibility of the owner to determine which notation is most suitable for his requirements.

Other Notations

112 Descriptive notations may be entered in the Register Book when deemed necessary by the Committee to indicate any special features in the design or construction of a ship or its machinery or to indicate any special service.

Section 2

EQUIPMENT

201 The figure 1 in the character of classification assigned to a ship indicates that her equipment of anchors, chain cables and hawsers is in good and efficient condition and in the cases of ships not classed for a special or restricted service, in accordance with the requirements of the Rules. In the case of ships classed for a special or restricted service, the figure 1 indicates that the equipment has been approved by the Committee as suitable for the particular service.

202 When the equipment of a ship is not supplied or maintained in accordance with the requirements of the Rules but is considered by the Committee to be acceptable for the particular service, the Committee may agree to the figure 1 being omitted and a line inserted after the character, thus, 100A–. In cases where the equipment is found to be seriously deficient in quality or quantity, the class of the ship will be liable to be withheld or expunged from the Register Book. Special consideration will be given to ships intended to be classed for which, by reason of their particular purpose or service, normal equipment may be unnecessary. In such cases the figure 1 may be omitted from the character of classification, viz. 100A.

Section 3

MACHINERY

301 The machinery, as defined in B 101, is to be constructed and installed on board ship in accordance with the Society's Rules and Regulations. On satisfactory completion of trials, an appropriate class notation will be assigned in the Register Book, thus, LMC (Lloyd's Machinery Certificate).

Section 4

MATERIALS

401 The materials used in the construction of hulls and machinery intended for classification, or in the repair of ships already classed, are to be of good quality and free from defects and are to be tested under the supervision of the Society's Surveyors in accordance with the requirements of Chapter P. The steel is to be manufactured by an approved process at works recognised by the Committee.

Section 5

EQUIVALENT ARRANGEMENTS

501 Alternative arrangements will be permitted, provided they are considered by the Committee to be equivalent to the Society's requirements. The Owners' consent shall be obtained to such alternatives when the Committee deem this necessary.

Section 6

NEW CONSTRUCTION

Submissions of Plans

601 When it is intended to build a ship for classification with the Society, constructional plans and particulars of the hull, equipment and machinery (*see* B 101), as detailed in the Rules, are to be submitted through the local Surveyors for the approval of the Committee before the work is commenced.

Any subsequent modifications or additions to the scantlings, arrangements or equipment shown on the approved plans are also to be submitted for approval.

Novel Forms of Construction

602 Where the proposed construction of any part of the hull or machinery is novel in design, or involves the use of unusual material, or where experience, in the opinion of the Committee, has not sufficiently justified the principle or mode of application involved, special tests or examinations before and during service may be required. A suitable notation will be inserted in the Register Book when the Committee consider this necessary.

Special Survey during Construction

603 New ships intended for classification are to be built under the Society's Special Survey and when classed will be entitled to the distinguishing mark ✠ inserted before the character in the Register Book, thus: ✠100A1.

New machinery for ships classed or intended for classification is to be constructed under the Society's Special Survey, and on completion will be entitled to the distinguishing mark ✠ inserted before the machinery class notation in the Register Book, thus: ✠LMC.

From the commencement of the work until the completion of the ship and final test of the machinery under working conditions, the Surveyors are to examine the materials, workmanship and arrangements. Any items not in accordance with the Rules or the approved plans, or any material, workmanship or arrangement found to be unsatisfactory are to be rectified.

Date of Build

604 The date of completion of the Special Survey during Construction of ships built under the Society's inspection will normally be taken as the date of build to be entered in the Register Book. If the period between launching and completion or commissioning is, for any reason, unduly prolonged, the dates of launching and completion or commissioning may be separately indicated in the Register Book.

When a ship upon completion is not immediately put into commission, but is laid up for a period, the Committee, upon application by the Owner, prior to the ship proceeding to sea, may direct an examination of the ship to be made in dry dock by the Society's Surveyors. If, as the result of such survey, the hull and machinery be reported in all respects free from deterioration, the subsequent Special Survey will date from the time of such examination.

Section 7

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

701 The requirements of the Committee for the classification of ships which have not been built under the Society's survey are set forth in C 11.

Section 8

PERIODICAL SURVEYS

Annual and Docking Surveys

801 All steel ships classed with the Society are subject to survey at intervals of approximately one year, in accordance with the requirements set forth in C 1.

Owners or their representatives should notify the Society or its Surveyors whenever a ship can be examined in dry dock or on a slipway. It is desirable that ships should be examined in dry dock at intervals of about 12 months ; the maximum interval is to be two years.

The date of the last examination in dry dock or on a slipway will be recorded in the Supplement to the Register Book.

Special Surveys

802 All steel ships classed with the Society are also to be subjected to Special Surveys in accordance with the requirements set forth in C 2 to C 7. These surveys become due at 4-yearly intervals, the first 4 years from the date of build or date of Special Survey for Classification, and thereafter 4 years from the date of the previous Special Survey.

Period allowed for completion of Special Surveys

803 When it is inconvenient for Owners to fulfil all the requirements of a Special Survey at its due date, the Committee will be prepared to consider its postponement, either wholly or in part, provided that the Society's Surveyors are afforded an opportunity, about the due date, of assessing the general condition of hull and machinery. For this purpose the Committee will normally call for a general examination of the ship, including drydocking, of sufficient extent to be assured that her condition is satisfactory for the period of grace desired, which is not to exceed 12 months from the due date.

Special Surveys which are commenced prior to their due date are not to extend over a period greater than 12 months, except with the prior approval of the Committee, who will be prepared to consider suitable arrangements for carrying out Special Surveys over an extended period in the case of ships engaged on a regular schedule.

Record of Special Surveys

804 Ships which have satisfactorily passed a Special Survey will have a record entered in the Supplement to the Register Book indicating the date. For Special Surveys at which the prescribed requirements as to drilling of the shell and strength deck plating have been complied with, the record (Dr) will be entered. Where a Special Survey is not completely carried out at one time, the date recorded in the Supplement will be the date at which the principal part of the requirements is complied with. Records of Special Survey will not be assigned until the Society's requirements for machinery surveys detailed in 806 or 807 are satisfactorily completed.

Continuous Surveys

805 When, at the request of the Owners, it has been agreed by the Committee that the complete survey of the hull may be carried out on the Continuous Survey basis, all compartments of the hull should be opened for survey and testing in rotation to ensure that the interval between consecutive examinations of each part will not exceed the period normally allowed by the Regulations between Special Surveys.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor.

Ships which have satisfactorily completed the cycle will have a record entered in the Supplement to the Register Book indicating the date.

Surveys of Machinery

806 Machinery, as defined in B 101, is to be submitted to the surveys set forth in C 4 to C 10.

Complete Surveys are to be carried out as part of the Special Survey and, whether or not they are commenced prior to their due date, are not to extend over a period greater than 12 months without approval. On satisfactory completion of the survey an appropriate record will be made in the Supplement to the Register Book. When a Complete Survey of the machinery is not carried out at one time the date recorded in the Supplement will be that on which the major portion of the survey is carried out.

If it is found desirable that any part of the machinery should be again examined before the due date of the next survey, a certificate for a limited period will be granted in accordance with the nature of the case.

Continuous Surveys of Machinery

807 When, at the request of Owners, it has been agreed by the Committee that the Complete Survey of the machinery may be carried out on the continuous survey basis, the various items of machinery should, so far as practicable, be opened for survey in rotation to ensure that the interval between consecutive examinations of each item will not exceed the four-yearly period normally allowed by the Regulations between Special Surveys.

In such cases a record indicating the date of completion of the cycle will be made in the Supplement to the Register Book.

Where it is inconvenient for Owners to carry out a Special Survey of a ship at its due date, and proposals for its postponement, either wholly or in part, have been submitted to and approved by the Committee, the Continuous Survey of the machinery should still proceed as described above during the period of postponement of the Special Survey.

If the examination during Continuous Survey reveals any defects, further parts are to be opened up and examined as considered necessary by the Surveyor and the defects made good to his satisfaction.

Boiler, Steam Pipes and Screw Shaft Surveys

808 Boiler Surveys, examination of Steam Pipes and Screw Shaft Surveys should be carried out as set forth in C 8, C 9 and C 10. On satisfactory completion, appropriate records will be made in the Supplement to the Register Book.

Section 9

REFRIGERATION

901 On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Supplement.

902 The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port and other Surveys set forth in N 8.

Section 10

REPAIRS AND ALTERATIONS

Repairs

1001 All repairs to hull, equipment and machinery which may be required in order that a ship may retain her class are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors. When repairs are effected at a port where there is no Surveyor to this Society, the ship is to be surveyed by one of the Society's Surveyors at the earliest opportunity.

1002 When at any survey the Surveyors consider repairs to be necessary, either as a result of damage, or of wear and tear, they will communicate their recommendations at once to the Owners, or their representative, and if compliance therewith cannot be arranged, immediate notification will be given by the Surveyors to the Committee.

Alterations

1003 Plans and particulars of any proposed alterations to the approved scantlings and arrangements of hull, equipment, or machinery are to be submitted for approval and such alterations are to be carried out under the inspection of, and to the satisfaction of, the Society's Surveyors.

Section 11

APPEAL FROM SURVEYORS' RECOMMENDATIONS

1101 If the recommendations of the Society's Surveyors are considered in any case to be unnecessary or unreasonable, appeal may be made to the Committee, who may direct a special examination to be held.

Section 12

NOTICE OF SURVEYS

1201 It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Special Surveys become due, but the non-receipt of such notice, or of notice regarding other surveys, does not absolve Owners from this responsibility.

Section 13

CERTIFICATES

1301 When the required reports on completion of the Special Surveys of new ships, or of existing ships submitted for classification, have been received from the Surveyors and approved by the Committee, certificates of first entry of classification, signed by the Chairman, Deputy-Chairman and Treasurer, or Deputy-Chairman and Chairman of the Sub-Committees of Classification, and countersigned by the Secretary, will be issued to Builders or Owners.

1302 Certificates of class maintenance in respect of completed periodical surveys of hull and machinery will also be issued to Owners on application.

1303 The Society's Surveyors are permitted to issue provisional certificates to enable a ship, classed with the Society, to proceed on her voyage provided that, in their opinion, she is in a fit and efficient condition. Such certificates will embody the Surveyor's recommendations for continuance of class, but in all cases are subject to confirmation by the Committee.

Section 14

WITHDRAWAL OF CLASS

Owners' Request

1401 When the class of a ship, for which the Regulations as regards surveys on hull, equipment and machinery have been complied with, is withdrawn by the Committee in consequence of a request from the Owners, the notation "Class WITHDRAWN at Owners' request" (with date) will be made in the Supplement and the notation "LR class w'drn." (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

Non-Compliance with the Regulations

1402 When the Regulations as regards surveys on the hull or equipment or machinery have not been complied with and the ship thereby is not entitled to retain her class, the class will be expunged and the notation "Class EXPUNGED—Non-compliance with Regulations" (with date) will be made in the Supplement and the notation "LR class expgd." (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

Reported Defects

1403 When it is found from reported defects in the hull or equipment or machinery that a ship is not entitled to retain her class in the Register Book, and the Owners fail to repair such defects in accordance with the Society's requirements, the class will be expunged and the notation "Class EXPUNGED—Reported defects" (with date) will be made in the Supplement and the notation "LR class expgd." (with date) will be made in the next reprint of the Register Book. After one year the notation will be altered to "Classed LR until" (with date).

Infringement of Freeboard Conditions

1404 Where any ship proceeds to sea with a less freeboard than that approved by the Committee or where the freeboard marks are placed higher on the ship's sides than the position assigned or approved by the Committee, the ship's class will be liable to be expunged.

Section 15

RECLASSIFICATION OF SHIPS

1501 When reclassification is desired for a ship for which the class previously assigned has been withdrawn, or expunged, the Committee will direct a Special Survey for Reclassification, appropriate to the age of the ship and the circumstances of the case, to be carried out by the Society's Surveyors.

If at such survey the ship be found or placed in a good and efficient condition in accordance with the requirements of the Rules and Regulations the Committee will be prepared to reinstate her original class or assign such other class as may be deemed necessary.

The date of reclassification will be recorded in the Supplement to the Register Book.

20th July, 1961

Chapter C

PERIODICAL SURVEY REGULATIONS

Section 1

ANNUAL SURVEYS

101 Annual Surveys as required by B 801 should, whenever practicable, be held concurrently with statutory annual or other load line surveys.

102 When a ship is in dry dock or on a slipway she is to be placed on blocks of sufficient height and proper staging is to be erected as may be necessary for the examination of the shell plating, sternframe and rudder.

103 The Surveyor is to examine the ship externally and, as necessary, internally in order to satisfy himself generally as to her condition. Attention is to be given to parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing, lying on the ground or handling of cargo. Attention is also to be given to any undue unfairness of the plating of the bottom or strength decks and to structural discontinuities and corners of openings in the strength decks and topsides.

104 When a statutory load line survey is held concurrently with the annual classification survey, the Surveyor will carry out such examination of the conditions of freeboard assignment as is required by the Load Line Regulations. In any case, however, the Surveyor at an Annual Survey is to satisfy himself as to the efficient condition of the following:—

Hatchways and their closing and securing appliances on freeboard and superstructure decks.

Exposed casings, superstructure bulkheads, companionways, ventilator coamings, air pipes, fiddley openings, flush bunker scuttles, and skylights with their closing appliances, which protect openings in freeboard or superstructure decks.

Gangways, cargo and coaling doors, ash shoots and other openings in the ship's sides, with their securing appliances; also freeing port shutters in bulwarks.

The Surveyor should satisfy himself regarding the freeboard marks on the ship's side.

105 The Surveyors are to examine the steering arrangements. Attention is to be paid to the examination of all parts of rod and chain gears. All pins are to be examined and the chain in the vicinity of the blocks is to be cleaned and examined for wear and tear. Any length of chain so worn that its mean diameter at its most worn part is reduced to the size given in Chapter D, Table 55, is to be renewed.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as set forth for short link cables in P 13 and the certificates are to be produced. It is recommended that, in addition, the breaking test as required in P 13 should be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect produced.

It is recommended that a set of spares as required by D 2710 be provided.

The various parts of the auxiliary steering gear are to be assembled and examined in order to ascertain that the gear is in good and workable condition.

106 The windlass, anchors and general equipment so far as accessible are to be examined.

When chain cables are ranged they should be examined by the Surveyor.

Masts and rigging are to be examined by the Surveyor when deemed necessary on occasions other than Special Surveys.

107 The requirements for the survey of main and auxiliary engines, boilers and electrical equipment, are set forth in C 4 to C 10.

Surveys for Damage or Alterations

108 At any time when a ship is undergoing damage repairs or alterations, any exposed parts of the structure normally difficult of access should be specially examined, e.g., if any part of the main or auxiliary machinery, including boilers, or insulation or fittings is removed for any reason the steel structure in way should be carefully examined by the Surveyor, or when cement in the bottom or covering on decks is removed the plating in way should be examined before the cement or covering is relaid.

Section 2

SPECIAL SURVEYS—HULL REQUIREMENTS

(*For Tankers, see also* C 3.)

(A) At the Special Survey of ships under 5 years old

201 The ship is to be placed on blocks of sufficient height in a dry dock, or on a slipway; proper staging is to be erected as necessary and the shell plating, sternframe and rudder are to be examined.

The rudder is to be lifted for examination of pintles if deemed necessary by the Surveyor.

202 The holds, peaks, deep tanks, engine and boiler spaces, coal bunkers and other spaces are to be cleared and cleaned as necessary and examined. The bilges and limbers all fore and aft are to be cleaned and the structure examined. Platform plates in engine and boiler spaces are to be lifted as may be necessary for the examination of the structure below.

Where necessary close and spar ceiling, lining and pipe casings are to be removed for examination of the structure.

203 In ships having a single bottom, a sufficient amount of close ceiling is to be lifted all fore and aft on each side from the bottom and bilges to permit the structure below to be examined. Where the ceiling is fitted in hatches, these are to be lifted.

204 In ships having a double bottom, a sufficient amount of ceiling is to be removed from the bilges and inner bottom to enable the condition of the plating to be ascertained. If it is found that the plating is clean and in good condition, and free from rust, the removal of the remainder of ceiling may be dispensed with. The Surveyor may waive the removal of heavy reinforced compositions if there is no evidence of leakages, cracking or other faults in the composition.

205 The steelwork is to be exposed and cleaned as may be required for its proper examination by the Surveyor. Careful examination is to be made of parts of the structure particularly liable to excessive corrosion or to deterioration from causes such as chafing, lying on the ground, or handling of cargo.

Attention is to be given to the examination of gangway, cargo or coaling doors, ash shoots and to the shell plating in way of these and other openings.

The Surveyor may require to ascertain by drilling or other approved means, the thickness of the material in any portion of the structure where signs of wastage are evident or wastage is normally found. Any parts of the structure which are found defective or materially reduced in scantlings are to be made good by materials of the approved scantlings and quality. Attention is to be given to the structure in way of discontinuities. Surfaces are to be recoated as necessary.

206 In cases where the inner surface of the bottom plating is covered with cement, asphalt or other composition the removal of this covering may be dispensed with, provided it be carefully inspected, tested by beating or chipping, and found sound and adhering satisfactorily to the steel.

207 Double bottom compartments, peak tanks and all other tanks are to be tested by a head sufficient to give the maximum pressure that can be experienced in service.

Tanks may be tested afloat provided their internal examination is also carried out afloat.

Tanks forming parts of the main structure, except as stated below, are to be cleaned and examined internally, special attention being given to tanks under boiler spaces. Tanks (excluding peak tanks) used exclusively for carrying oil fuel need not be examined internally, provided after external examination and testing in accordance with the requirements set out above, the Surveyor finds the condition of these compartments satisfactory.

208 All decks, machinery and other casings, superstructures, skylights, companionways, ventilators, and air pipes together with all opening and closing appliances, are to be examined. Attention should be given to the examination of strength decks and topsides in way of the corners of openings and at other discontinuities.

209 Wood decks or sheathing are to be examined; if decay or rot is found or the wood is excessively worn it should be renewed. When a wood deck, laid on stringers and ties, originally required to be 3 inches is worn to $2\frac{1}{2}$ inches, or $2\frac{1}{2}$ inches to 2 inches, it is to be renewed.

Attention is to be given to the condition of the plating under wood decks, sheathing or other deck covering. If it is found that such coverings are broken or are not adhering closely to the plating, sections should be removed as necessary to ascertain the condition of the plating. (*See also* C 108.)

210 The hatchway coamings are to be examined. Covers, hatch beams and supports throughout, tarpaulins, cleats, battens and other means of securing the hatchways, are to be examined separately and in position. Attention should be paid to the means of ensuring watertightness of steel hatch covers.

211 The masts, rigging, anchors and general equipment are to be examined. If the chain cables are ranged they should be examined. (*See* Chapter D, Table 55, for renewals.)

212 The steering gear, and its connections and control gear are to be examined and all parts of rod and chain gears are to be dismantled, cleaned and examined. (*See also* C 402, Steering Machinery.) Any length of chain so worn that its mean diameter at its most worn part is reduced to the size given in Chapter D, Table 55, is to be renewed.

All replacements of chains are to be subjected, under the Society's supervision, to the proof tests as given for short link cables in P 13, and the certificates are to be produced. It is recommended that, in addition, the breaking test as required in P 13 should be applied to these chains, and that the tests be made at a proving establishment recognised by the Committee.

It is recommended that repaired chains be tested by the repairers and a certificate to that effect produced.

It is recommended that a set of spares as required by D 2710 be provided.

The various parts of the auxiliary steering gear are to be assembled and examined to ascertain that the gear is in good and workable condition.

213 The windlass (*see* C 402), pumps, suctions, watertight doors, sidescuttles and deadlights, freeing port shutters, overboard scuppers and discharge pipes, and air and sounding pipes are to be carefully examined.

When examining tanks internally the Surveyor is to see that striking plates are fitted under sounding pipes.

214 Where holds are insulated for the purpose of carrying refrigerated cargoes, and the hull in way of the insulation was examined by the Society's Surveyors at the time such insulation was fitted, it will be sufficient to remove the limbers and hatches to enable the framing and plating in way to be examined; in other cases additional insulation is to be removed as necessary to satisfy the Surveyor as to the condition of the structure. (*See also* N 8.)

215 The freeboard recorded in the Appendix to the Register Book is to be verified.

216 The main and auxiliary engines and boilers and electrical equipment are to be examined in accordance with the requirements of C 4 to C 10 and favourably reported on by the Society's Engineer Surveyors.

(B) At each Special Survey of ships between 5 and 10 years old.—THE FULL REQUIREMENTS OF 201 TO 216 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

217 A sufficient amount of ceiling in the holds and in coal bunkers is to be removed from the bilges and inner bottom to enable the condition of structure in the bilges, the inner bottom plating, pillar feet, and the bottom plating of bulkheads and tunnel sides to be examined. If the Surveyor deems it necessary, the whole of the ceiling is to be removed.

218 In ships having a single bottom the limber boards and ceiling equal to not less than three strakes all fore and aft on each side are to be removed, one such strake being taken from the bilges. Where the ceiling is fitted in hatches, the whole of the hatches and at least one strake of ceiling in the bilges are to be removed. If the Surveyor deems it necessary the whole of the ceiling and limber boards are to be removed.

219 Tanks used exclusively for oil fuel need not all be internally examined, provided the Surveyor is satisfied from an external examination and from a check internal examination of the midship end of one selected double bottom tank forward and one aft and of one selected deep tank.

Lubricating oil tanks need not be examined internally.

220 The chain cables are to be ranged for inspection, and the anchors and chains examined. If any length of chain cable is found to be reduced in mean diameter at its most worn part to the extent indicated in Chapter D, Table 55, it is to be renewed.

221 The chain locker is to be cleaned and examined internally.

(C) At each Special Survey of ships over 10 years old.—THE FULL REQUIREMENTS OF 201 TO 221 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

222 The steel work is to be cleaned and the rust removed.

223 Casings of air, sounding, steam and other pipes, spar ceiling and lining in way of the sidescuttles are to be removed as required by the Surveyor.

224 If the Surveyor is satisfied after removal of portions of the ceiling in the holds, that the steel work is in good condition, free from rust, and coated, the removal of the whole may be dispensed with. In coal bunkers, however, the whole of the ceiling is to be removed.

225 Attention is to be given by the Surveyor to the inside of coal bunkers and the parts in way of the boilers.

226 Attention is also to be paid to the possibility of local wastage and grooving, e.g., at the shell plating along the heel of framing members.

227 All double bottom and other tanks, including oil fuel bunkers, are to be cleaned as necessary to permit of their being examined internally.

228 The cement chocks on the ship's sides at bilges and decks are to be examined, and portions removed, so that the condition of the shell plating and adjacent steel work can be ascertained. Portions of wood sheathing, or other covering, on steel decks are to be removed as considered necessary by the Surveyor in order to ascertain the condition of the plating.

229 Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted, and sufficient insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the framing and plating. (*See also* N 8.)

230 All mast wedging is to be removed and renewed as necessary.

(D) At the first Special Survey held after the ship is 24* years old and at every 12* years thereafter or at the next Special Survey after the expiration of the latter period—THE FULL REQUIREMENTS OF 201 TO 230 ARE TO BE COMPLIED WITH, TOGETHER WITH THE FOLLOWING :—

231 In addition to the drilling required by 205 to ascertain local wastage the shell plating and plating of strength decks are to be gauged by drilling or other approved means to determine the amount of any general diminution in thickness. The gauging is to be done in at least two places in each strake of plating on each side within the amidships half length, preferably clear of coal bunkers and deep tanks.

All paint and rust is to be entirely removed before the plates are gauged by the Surveyor and the actual thicknesses are to be reported in detail to the Committee. Where drilled plates are renewed the thickness of adjacent plates in the same strake should be reported.

The thickness of bottom plating in way of cement is to be ascertained unless the Surveyor, after an internal and external examination, is entirely satisfied that this is unnecessary. Selected portions of the cement are to be removed from the bottom and bilge if required by the Surveyor.

232 Where the holds are insulated for the purpose of carrying refrigerated cargoes, the limbers and hatches are to be lifted, and sufficient additional insulation is to be removed in each of the chambers to enable the Surveyor to satisfy himself of the condition of the steel structure, and to enable the thickness of the shell plating to be ascertained as required by 231.

* *For tankers see* C 306.

Section 3

SPECIAL SURVEYS—TANKERS

HULL REQUIREMENTS ADDITIONAL TO THOSE STATED IN C 2

Preparation and Inspection of Tanks

301 At all Special Surveys all cargo tanks and cofferdams are to be cleaned out, thoroughly cleared of gas, and examined. Every precaution is to be taken to ensure safety during inspection.

Attention is to be given to the inside of the bottom plating in order to ensure that there is no excessive pitting of the plating. When extensive pitting is found care should be taken to preserve the longitudinal strength of the bottom by the requisite renewals or repairs. In cases where cement has been laid in the bottom the Surveyor is to satisfy himself that there is no active corrosion under the cement.

302 The strums of the cargo suction pipes are to be removed to facilitate examination of the shell plating and bulkheads in that vicinity, unless other means for visual inspection of these parts are provided.

Testing

303 Each cargo tank bulkhead is to be tested at Special Surveys A and B by filling alternate tanks with water to the top of the hatchway. But at subsequent Special Surveys, or earlier if considered necessary by the Surveyor, all tanks are to be tested.

304 Tanks may be tested when the ship is afloat, provided the internal examination of the bottom is also carried out afloat.

305 Where extensive repairs have been effected to the shell plating, the tanks should be tested to the Surveyor's satisfaction.

Drilling

306 The thickness of shell and deck plating in way of tanks is to be ascertained by drilling or other approved means at the first Special Survey after the ship is 12 years old and at every 8 years thereafter or at the next Special Survey after expiration of the latter period. (*See* C 231.)

Section 4

GENERAL REQUIREMENTS—MACHINERY

APPLICABLE TO ALL SHIPS

At each Survey held in dry dock

401 When the ship is in dry dock the propeller, sternbush and sea connection fastenings are to be examined. The wear down of the sternbush or the efficiency of the oil gland should be ascertained.

Special Surveys—Machinery Requirements

402 At each Complete Survey required by B 806 the following parts are to be opened up and examined:—

SEA CONNECTIONS

While the ship is in dry dock all openings to the sea in the machinery spaces and pump rooms with the valves, cocks and the fastenings with which these are connected to the hull.

SHAFTING

All shafts (except screw and tube shafts for which special arrangements are detailed in C 1001), thrust block and all bearings. The lower halves of bearings need not be exposed if alignment and wear are found acceptable.

REDUCTION GEARS, complete with all wheels, pinions, shafts, bearings and gear teeth.

AUXILIARY ENGINES, auxiliary air compressors with their intercoolers and safety devices, and all pumps and components used for essential services.

STEERING MACHINERY.

WINDLASS.

EVAPORATORS and their safety valves, which should be seen in operation under steam.

SECURING ARRANGEMENTS

The holding down bolts and chocks of main and auxiliary engines, gear cases, thrust blocks and tunnel bearings.

AIR RECEIVERS

All air receivers for essential services with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

PUMPING ARRANGEMENTS

The valves, cocks and strainers of the bilge system including bilge injection, are to be opened up as considered necessary by the Surveyor and, together with pipes, are to be examined and tested under working conditions. The oil fuel, feed and lubricating oil systems and the ballast connections and blanking arrangements to deep tanks which may carry liquid or dry cargoes, together with all pressure filters, heaters and coolers used for essential services, are to be opened up and examined or tested as considered necessary by the Surveyor. All safety devices for the foregoing items are to be examined.

FUEL TANKS AND FITTINGS

Fuel tanks which do not form part of the ship's structure are to be examined and if considered necessary by the Surveyor they are to be tested to the pressure specified for new tanks. The tanks need not be examined internally at the first survey if they are found satisfactory on external inspection. All mountings, fittings and deck controls are to be examined as far as practicable.

FIRE EXTINGUISHING SYSTEMS IN MACHINERY SPACES AND PUMP-ROOMS

The apparatus is to be examined to ensure that it is maintained in an efficient condition.

In addition to the above, detailed requirements for steam and internal combustion engines, electrical installations and boilers are given in C 5, C 6, C 7 and C 8 respectively.

Section 5

STEAM ENGINES—DETAILED REQUIREMENTS

Complete Surveys

501 In addition to the requirements of C 4 the working parts of the main engines and attached pumps and of auxiliary machinery used for essential services including bulkhead stop valves, manœuvring valves, cylinders, pistons, valves and valve gear, piston rods, connecting rods, crossheads and guides, the crank shafts of reciprocating engines and the blading, rotors and casings of turbine machinery are to be opened up and examined.

Condensers, steam reheaters, desuperheaters which are not incorporated in the boilers and any other appliances used for essential services are to be examined to the satisfaction of the Surveyor, and if considered necessary they are to be tested.

The manœuvring of the engines is to be tested under working conditions.

502 Exhaust steam turbines supplying power for main propulsion purposes in conjunction with reciprocating engines are, together with their gearing and appliances, steam compressors or electrical machinery, to be examined as far as practicable. Where cone connections to internal gear shafts are fitted, the coned ends are to be examined as far as practicable.

503 In steam ships having essential auxiliary machinery driven by internal combustion engines, the prime movers of these auxiliaries are to be examined as detailed in C 601.

Section 6

INTERNAL COMBUSTION ENGINES—DETAILED REQUIREMENTS

Complete Surveys

601 In addition to the requirements of C 4 the Complete Survey is to consist of the opening out and examination of the following parts: cylinders, covers, valves and valve gear, fuel pumps and fittings, scavenge pumps, scavenge blowers and their prime movers, superchargers, compressors, their intercoolers and safety devices, pistons, piston rods, crossheads, guides, connecting rods, crank shafts and all bearings, clutches, reverse gears, attached pumps, cooling system, crankcase door fastenings and explosion relief devices. The electric ignition system, if fitted, is to be examined and tested. The manœuvring of engines is to be tested under working conditions.

Where steam is used for essential purposes, the condensing plant, feed pumps, and oil fuel burning plant, are to be examined and the steam pipes examined and tested as detailed in C 9.

602 Gas turbines and free piston gas generators: in addition to the requirements of C 4, the Complete Survey is to consist of the opening and examination of the following parts: the blading, rotors and casings of the turbines, the impellers or blading, rotors and casings of the air compressors, the combustion chambers, burners, intercoolers, heat exchangers, gas and air pressure piping and fittings, starting and reversing arrangements.

Where gas turbines operate in conjunction with free piston gas generators, the following parts of the latter are to be opened and examined: the gas and air compressor cylinders and pistons and the compressor end covers, the valves and valve gear, fuel pumps and fittings, synchronising and control gear, cooling system, explosion relief devices, gas and air piping, receivers and valves including by-pass. The manœuvring of engines is to be tested under working conditions.

Section 7

ELECTRICAL EQUIPMENT

701 At each Special Survey the electrical equipment is to be examined and tested in accordance with 702 to 710.

NOTE.—In cases where the Committee have consented to Continuous Surveys, the electrical equipment may also be included in the survey cycle. (*See* B 807.)

702 A test for insulation resistance is to be made on the cables, switchgear, generators, motors, heaters, lighting fittings, etc., and the insulation resistance is to be not less than 100,000 ohms between all insulated circuits and earth. The installation may be sub-divided to any desired extent by opening switches, removing fuses or disconnecting appliances for the purpose of this test.

703 The fittings on main and emergency switchboards, section boards and sub-distribution fuse boards are to be examined and over-current protective devices and fuses inspected to verify that they provide suitable protection for their respective circuits.

704 Generator circuit breakers are to be tested, as far as practicable, to verify that the protective devices including preference tripping relays, if fitted, operate satisfactorily.

705 The electric cables are to be examined as far as practicable without undue disturbance of fixtures or casings unless opening up is considered necessary as a result either of observation or of the tests required by 702.

706 The generator prime movers are to be surveyed as required by C 5 and C 6 and the governing of the engines tested. The motors concerned with essential services together with associated control and switch gear are to be examined and if considered necessary are to be operated as far as practicable under working conditions. All generators and steering gear motors are to be examined and are to be operated under working conditions though not necessarily under full load or simultaneously.

707 Where transformers or electrical apparatus associated with supplies to essential services are oil-immersed, the Owners are to arrange for samples of oil to be taken and tested for breakdown voltage, acidity and moisture by a competent testing authority and a certificate giving the test results is to be furnished to the Surveyor.

708 Where electro-magnetic couplings are fitted, the air gaps are to be measured and reported and any excessive eccentricity corrected. The couplings and associated switch gear are to be examined and tested.

709 Navigation light indicators are to be tried under working conditions and correct operation on the failure of supply and failure of navigation lights verified.

Electric Propelling Machinery

710 Where the ship is electrically propelled, the propulsion motors, generators, cables, and all ancillary electrical gear, exciters and ventilating plant (including coolers) associated therewith are to be examined and the insulation resistance to earth is to be tested. Special attention is to be given to windings, commutators and slip-rings. The operation of protective gear and alarm devices is to be checked as far as practicable. Insulating oil, if used, is to be tested in accordance with 707. Interlocks intended to prevent unsafe operations or unauthorised access are to be checked to verify that they are functioning correctly. Emergency overspeed governors are to be tested.

Section 8

BOILER SURVEYS

801 All boilers, including exhaust gas or steam heated steam generators, economisers, domestic boilers having a working pressure exceeding 50 lb per square inch and a heating surface exceeding 50 square feet, also press boilers and similar apparatus in floating whale oil factories are to be surveyed at two-yearly intervals until they are 8 years old and subsequently annually. In boilers employing forced circulation the pumps used for this service are to be opened and examined at each boiler survey.

802 At the surveys described in 801 the boilers, superheaters and economisers are to be examined internally and externally and where considered necessary the pressure parts are to be tested by hydraulic pressure and thickness of plates and tubes and size of stays are to be ascertained to determine a safe working pressure. The principal mountings on boilers, superheaters and economisers are to be opened up and examined and the safety valves adjusted under steam to a pressure not greater than 3 per cent above the approved working pressures of the respective parts. The remaining mountings are to be examined externally and are to be opened up for internal examination if considered necessary by the Surveyor. Collision chocks, rolling stays and boiler stools are to be examined and maintained in efficient condition.

803 The oil fuel burning system is to be examined under working conditions and a general examination made of fuel tank valves, pipes, deck control gear and oil discharge pipes between pumps and burners.

804 At each survey of a cylindrical boiler which is fitted with smoke tube superheaters, the saturated steam pipes are to be examined as detailed in C 905.

Section 9

STEAM PIPES

Steel Pipes

901 At intervals of 6 years from the date of build, a selected number of main and superheater steam pipes and auxiliary steam pipes over 3 inches internal diameter, supplying steam for essential purposes at sea, are to be removed for internal examination and hydraulically tested to twice the working pressure.

902 If these selected pipes are in all respects found to be satisfactory, the remainder need not be tested.

903 In cylindrical boilers having smoke tube superheaters where the saturated steam pipes adjoining the saturated steam headers are in part situated in the boiler smoke boxes, all saturated steam pipes adjoining and cross-connecting the saturated steam headers in the smoke boxes are, at the above-mentioned intervals, to be included in the number of pipes selected for examination.

904 Where the saturated steam pipes inside the smoke boxes consist of steel castings of substantial construction the requirements of 903 need only be applied to a sample casting.

905 Where the steel castings in 904 are not fitted the Surveyor should satisfy himself of the condition of the ends of the saturated steam pipes inside the smoke boxes at each boiler survey, and if it is considered necessary a sample pipe should be removed for further examination.

906 As an alternative to the requirements of 901 and provided the saturated steam pipes are dealt with as detailed in 903, 904 and 905, the remainder of the steam pipes may, at the Owners' desire, be hydraulically tested in place to twice the working pressure. Lagging is to be removed as required by the Surveyor to permit effective examination.

Copper Pipes

907 At intervals of 6 years from the date of build all copper steam pipes over 3 inches internal diameter (except those covered by 908) supplying steam for essential services at sea are to be tested hydraulically to twice the working pressure. Pipes in this category which may be subject to bending and/or vibration, such as those having expansion or other bends, and closing lengths adjacent to steam driven machinery, are are to be annealed before being tested.

908 Copper pipes with brazed longitudinal joints are to be hydraulically tested to twice the working pressure at 4-yearly intervals. Pipes which may be subject to bending and/or vibration, such as those having expansion or other bends, and closing lengths adjacent to steam driven machinery, are to be annealed before being tested.

Section 10

SCREW SHAFTS AND TUBE SHAFTS

1001 Screw shafts and tube shafts are to be drawn periodically for examination by the Society's Surveyors.

Where shafts are fitted with continuous liners or approved oil glands or are made of approved corrosion-resisting material, they normally become due for survey at intervals of 3 years for single screw ships and 4 years for ships having two or more screws. All other shafts should be drawn at intervals of 2 years.

On the application of Owners, the Committee will be prepared to give consideration to the circumstances of any special case.

Section 11

CLASSIFICATION OF SHIPS NOT BUILT UNDER SURVEY

1101 When classification is desired for a ship not built under the supervision of the Society's Surveyors, application should be made to the Committee in writing.

Hull and Equipment

1102 Plans showing the main scantlings and arrangements of the actual ship and any proposed alterations are to be submitted for approval. These should comprise midship section, longitudinal section and decks, and such other plans as may be requested. If plans cannot be obtained or prepared by Owners, facilities are to be given for the Society's Surveyor to take the necessary information from the ship.

Particulars of the process of manufacture and testing of the material of construction should be furnished.

1103 In all cases the full requirements of C 201 to C 230 are to be carried out. In the case of tankers the requirements of C 301 to C 305 are also to be carried out. Tankers over 12 years old are in addition to comply with C 306, and other ships over 20 years old with C 231 and C 232. During the survey the Surveyors are to satisfy themselves regarding the workmanship and verify the approved scantlings and arrangements. For this purpose, and in order to ascertain the amount of any deterioration, parts of the structure will require to be drilled as necessary. Full particulars of the anchors, chain cables and equipment are to be submitted.

Ships of recent construction will receive special consideration.

1104 When the full survey requirements indicated above cannot be completed at one time, the Committee may consider granting an interim record for a limited period. The conditions regarding the completion of the survey will depend on the merits of each particular case, which should be submitted for consideration.

Machinery

1105 To facilitate the survey, plans of the following items, together with the particulars of the material used in the construction of the boilers, air receivers and important forgings should be furnished:—

General pumping arrangements, including air and sounding pipes. (Shipbuilder's plan.)
Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.
General arrangement of cargo piping in tanks and on deck of oil tankers.
Piping arrangements for cargo oil (F.P. above 150° F.).
Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service.
Arrangement and dimensions of main steam pipes.
Arrangements of oil fuel pipes and fittings at settling and service tanks.
Arrangements of oil fuel piping in connection with oil burning installations.
Oil fuel and cargo oil overflow systems, where these are fitted.
Arrangement of boiler feed systems.
Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.
Plans of machinery space piping are to be diagrammatic.
Boilers, superheaters and economisers.
Air receivers.
Crank, thrust, intermediate and screw shafting.
Clutch and reversing gear with methods of control.
Reduction gearing.
Electrical circuits.

NOTE.—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

TORSIONAL VIBRATION CHARACTERISTICS

For new ships and ships which have been in service less than 8 years calculations of the torsional vibration characteristics of the propelling machinery are to be submitted for consideration as required for ships constructed under Special Survey. For older ships the circumstances will be specially considered in relation to their service record and type of machinery installed.

Where calculations are not submitted the Committee may require that the machinery certificate be endorsed to this effect.

When desired by the Owners the calculations and investigation of torsional vibration characteristics of machinery may be carried out by the Society upon special request.

1106 The main and auxiliary machinery, also feed pipes, compressed air pipes and boilers are to be examined as required at Special Surveys, and their working pressures are to be determined from their actual scantlings in accordance with the Rules.

The screw shaft is to be drawn and examined.

The steam pipes are to be examined and tested as required by C 9.

The bilge, ballast and oil fuel pumping arrangements are to be examined and amended as necessary to comply with the Rules.

Oil burning installations are to be examined as required at Special Surveys and found, or amended, to comply with the requirements of the Rules; they are also to be tested under working conditions.

The electrical equipment is to be examined as required at Special Surveys.

The fire extinguishing arrangements are to be in accordance with the requirements of the Rules (*see* Chapter F).

The whole of the machinery is to be tried under working conditions to the Surveyors' satisfaction.

First entry reports are to be prepared by the Surveyors.

Periodical Surveys

1107 Periodical surveys are subsequently to be held as in the case of ships built under survey.

16th June, 1960

Chapter D

STEEL SHIPS

Section 1

GENERAL

Determination of Scantlings

101 The scantlings in the Tables are related in general to basic dimensions and, where necessary, to a basic moulded draught. Corrections are given in the Tables, or associated notes, for use where the actual dimensions or draught of the ship differ from those in the Tables. The Rules and Tables are framed for ships of normal ratio of breadth to depth and having proportions of length to depth at the strength deck not exceeding thirteen and a half.

If the proportions are abnormal, special structural arrangements will be required.

The minimum scantlings given by the Tables may require to be increased on account of particular features in general design or when Owners desire to make provision for exceptional distributions or concentration of loading (*see* B 101, D 34 and Table 18, note 2(*e*)).

Assignment of Class

102 The class 100A1 will be assigned in accordance with the provisions of Chapter B to all sea-going ships when the requirements of the Rules have been complied with for the draught required.

Material

103 The Rules and Tables are based on the use of mild steel which complies with the requirements of Chapter P. Grade A steel (*see* P 2 Table II) may be used except where a higher grade is specifically required. As an alternative to Grade D, Grade C may be accepted, subject to compliance with the impact test requirements of Grade D. In special circumstances impact tests may not be required.

Where the physical characteristics of the steel are in excess of the requirements of P 2, or other material is used, the scantlings will be specially considered.

Method of Construction

104 The Rules and Tables set forth requirements for riveted construction together with certain modifications where electric arc welding is adopted.

Particulars indicating the principal parts which are electrically welded will be given in the Register Book as deemed desirable by the Committee.

Interpolation

105 For dimensions and draughts between the values given in the Tables the scantlings are to be obtained by interpolation.

Distribution of Material

106 The scantlings given in the Tables for the midship portion of the ship are to be reduced gradually to those given for the ends.

Equivalents

107 Alternative arrangements or fittings which are considered to be equivalent to the requirements of the Rules will be accepted by the Committee but the Owner's sanction may be required.

Submission of Plans

108 For each ship proposed to be built under survey for classification in the Register Book plans of midship and longitudinal sections, on which the designed summer moulded draught is to be given, together with the particulars necessary for calculation of freeboard, are to be submitted for approval.

The following plans are also to be submitted:—

Shell plating.
Decks.
Watertight bulkheads.
Pillars and girders.
Deep tanks.
Oil fuel bunkers.
Arrangements to resist panting.
Strengthening of bottom forward.
Rudder and sternframe.
Propeller brackets.
Bossed framing.
Motor and thrust seating.
Cruiser stern.
Long deckhouses.
Hatchways.
Main steering gear of rod and chain type and auxiliary steering gear.
Strengthening for navigation in ice.
Pumping arrangements.
Scheme of riveting.
Scheme of welding.

NOTE.—*It is recommended that a plan be carried in the ship indicating the positions and grades (other than Grade A) of hull structural steel, for the convenience of all concerned with repairs and renewals. This may be done by colouring the plan according to P 202, or by other appropriate means.*

Section 2

DEFINITIONS

201 **Length L** is the distance in feet on the summer load waterline from the fore side of stem to the after side of rudder post, or to the centre of rudder stock if there is no rudder post, but L is not to be less than 96 per cent of the extreme length on the summer load waterline.

Amidships is to be taken as the middle of the length L.

202 **Breadth B** is the greatest moulded breadth in feet.

203 **Depth D** is measured in feet at the middle of the length L from top of keel to top of deck beam at side.

D for Shell and Topside Plating is measured to the strength deck as defined in 207.

D for Framing is measured to the uppermost continuous deck.

204 **Draught d** is the summer draught in feet measured from top of keel.

205 **Depth h for Framing** is measured in feet from the top of the double bottom or single bottom floor at side to the top of beam at side of the lowest deck.

206 **Effective Superstructure** is a midship superstructure extending from side to side of the ship and exceeding ·15L in length.

207 **Strength Deck** is the uppermost continuous deck except in way of an effective superstructure where the superstructure deck is to be considered the strength deck.

208 **Passenger ship** is a ship, engaged on international voyages, which carries more than twelve passengers.

Section 3

KEELS, STEMS AND STERNFRAMES

Materials

301 Steel castings are to comply with the requirements of P 5.

302 Forgings made of ingot steel are to comply with the requirements of P 6.

303 If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

Plate Keels

304 The scantlings of plate keels are given in Table 14. Plate keels are to be associated with centre keelsons or centre girders as required by D 4 or D 5.

Bar Keels

305 The scantlings of bar keels are given in Table 1.

Riveted scarphs connecting the separate lengths together, or to the stem and sternpost, are to have a length of nine times the thickness of the bar.

Stems

306 Bar stems are to have the scantlings given in Table 1, but above the load waterline the dimensions may be gradually tapered to the stem head where the sectional area may be 75 per cent of the area derived from the Table.

307 If the stem is constructed of shaped plates the thickness of the plates below the load waterline is to be 10 per cent greater than the thickness of the side shell plating given in Table 14, col. 8, without corrections; above the load waterline the thickness may be gradually tapered towards the stem head where it may be equal to the shell plating at ends. Plates which require to be furnaced are to have these thicknesses when finished.

The plates are to be supported by horizontal webs between the decks and below the lowest deck; the unsupported length of the stem plates is not to exceed 5 feet. Where the radius of the plates is large a centre line stiffener may be required.

For strengthening of plate stems for navigation in ice, *see* D 1008, D 1016 and D 1024.

308 The separate lengths of the stem are to be efficiently connected and the lower end of the bar stem is to overlap the forward flat keel plate.

Sternframes

309 Sternframes may be of rectangular or streamlined section or may be of built construction to suit the lines of the ship. The scantlings are to be determined from Tables 2 and 3 and associated notes. Cast steel and built sternframes are to be strengthened at intervals by transverse webs of suitable thickness. Cast steel stern frames are to be simple in design and all fillets should have a large radius.

310 The lower part of the sternframe is to be extended forward to provide an efficient connection to the flat plate keel.

311 The rudder post is to be attached to a transom plate of the same depth as that required for double bottom floors and ·10 inch thicker than the floors (*see* Table 6, cols. 4 and 10); when the length of the ship exceeds 300 feet, the rudder post is to be connected to the transom by double

angles, double riveted in each flange. In single screw ships having cruiser sterns or exceeding 300 feet in length the propeller post is to be efficiently attached to a deep floor.

312 The sole piece under a propeller aperture is to be kept as short as possible and is to be increased in scantlings as required by Table 2, note 4.

313 The upper gudgeon is to be as near as practicable to the rudder trunk and rudder coupling. Gudgeons are to have a thickness of metal round the finished bore equal to half the diameter of the pintle and the depth is to provide full bearing surface for the pintle. The scantlings of pintles are to be determined from Table 47 and associated notes.

314 The length of the scarph in a sternframe of rectangular section is to be three times the fore and aft dimension of the post and the width of the scarph is to be half the length of the scarph. The thickness at the tip of the scarph is to be 13 per cent of the thickness of the post, and the connection is to be made by four rows of rivets. In single screw ships the scarph of the rudder post should not be fitted above the upper gudgeon. The strength of scarphs or other connections in cast steel streamlined sternframes is to be equivalent to the above requirements.

315 The scantlings and arrangements of propeller brackets and of sternframes in ships of relatively high power will be specially considered.

Cross-reference

316 For riveted connections to stems and sternframes, *see* Table 52 H.

Section 4

SINGLE BOTTOMS

Floor Plates

401 The scantlings of floor plates are to be determined from Table 4 and associated notes. Floors are to be fitted at every frame.

If a bar keel is fitted the floors are to be continuous from side to side; if a flat plate keel is adopted the floors may be continuous or cut at the centre line.

402 The floors at the bilges are to be attached to the frames by flanged brackets of the same thickness as the floor plates and having breadth and depth, clear of the frame and floor respectively, equal to the depth of the floor at the centre line.

Alternatively, the brackets may be omitted if the depth of the floor is increased by 15 per cent and the frame is reinforced at its junction with the floor plate.

403 The tops of floors are, in general, to be level from side to side but in ships having considerable rise of floor, and in all ships in the engine room and towards the ends, the depth of the floor plates is to be increased; the brackets may be dispensed with provided the side framing is adequately supported.

404 Floor plates forming part of a bulkhead are to be not less than 36 inches in depth measured at the centre line and the thickness is to be as required for the bottom strake of the bulkhead.

405 The side frames are to be efficiently attached to the floor plates.

Frames and Reversed Frames

406 Floors are to be attached to the bottom plating by single angles having the same thickness as the floor plates. (*See* D 807.)

407 Reversed frames on the upper edges of the floor plates are to have the scantlings given in Table 4.

Throughout the engine room, under the boiler bearers and in way of strengthening of bottom forward, the reversed frames are to be doubled from side to side.

Centre Keelsons

408 The scantlings of centre keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

409 In ships having a bar keel, the centre keelson is to consist of continuous double angles on top of the floors in conjunction with intercostal plates connected to the floors by single angles having the same thickness as the intercostal plates.

In ships not exceeding 160 feet in length the intercostal plates may be omitted provided the centre keelson bars are as required by Table 5 for tugs.

410 Plate keels are to be associated with plate keelsons having double continuous top angles. The keelson plates are to be connected to the keel by single angles except in the engine room, thrust recess and the forward ·25L where the connection is to be double. If the floors are continuous the keelson plates are to be intercostal and attached to the floors by single angles having the same thickness as the intercostal plates.

Where the floors are cut at the middle line they are to be connected to the continuous keelson plate by double angles having the thickness of the keelson plates. Continuous foundation plates are to be fitted at the top of the floors on each side of the keelson plate.

411 The butts of all continuous longitudinal material are to be efficiently strapped or welded.

Side Keelsons

412 The scantlings of side keelsons are given in Table 5. The keelsons are to extend as far forward and aft as practicable, and where cut at bulkheads the longitudinal strength is to be efficiently maintained.

413 One side keelson is to be fitted on each side of the centre line if the breadth B does not exceed 30 feet and two where B is above 30 feet and does not exceed 54 feet.

414 The keelsons are to consist of a continuous angle with the wider flange faying on the reversed frames.

Intercostal plates fitted between the floors are to be attached to the continuous angles and connected to the shell plating by single angles having the same thickness as the intercostal plates.

415 The butts of the continuous angles are to be efficiently strapped or welded.

416 In the engine room additional side keelsons are to be fitted.

Increased Thicknesses in Machinery Spaces

417 In the engine room the floors are to be increased in thickness by ·04 inch.

In the boiler room the floors, reversed frames, centre and side keelson plates and all angles not covered by cement are to be increased in thickness by ·10 inch.

Strengthening of Bottom Forward

418 The bottom structure forward is to be in accordance with the requirements of D 8.

Ships Loading or Discharging Aground

419 It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

Pumping and Drainage

420 The arrangements are to be in accordance with the requirements of Chapter E. Efficient provision is to be made to permit water from every part of the bottom to reach the pump suctions.

Section 5

DOUBLE BOTTOMS

Scantlings

501 The scantlings of the double bottom structure and the tank side connections are to be determined from Tables 6 to 11 and associated notes.

Centre Girder

502 The attachment of the centre girder to the keel plate and to the middle line strake of the inner bottom is to be by double angles, or equivalent connections, throughout in all ships exceeding 350 feet in length; in smaller ships the attachment need be double, or equivalent, only in the engine room, thrust recess and in the forward ·25L.

Intercostal Side Girders

503 In ships where the breadth B does not exceed 34 feet one stiffener is to be fitted to the floors on each side, about midway between the centre line and the margin plate. Where B exceeds 34 feet one intercostal side girder is to be fitted and where B exceeds 64 feet but does not exceed 80 feet two girders are to be fitted on each side of the centre line extending as far forward and aft as practicable. In the forward ·25L of all ships side girders are to be fitted as required by D 805.

504 In the machinery space and thrust recess the number and disposition of the side girders are to be such as to support the machinery effectively and to secure the necessary rigidity of structure. Double angles or equivalent connections are to be fitted on the upper edges of these girders under the engines and thrust seating.

505 Intercostal girders are not to be flanged in the forward ·25L, under the engine and thrust seating or under widely spaced pillars. Where intercostals are flanged their thickness is to be increased by 10 per cent.

506 If plate floors are fitted at every frame the intercostal girders, except in the engine room and in the forward ·25L, may be replaced by continuous bulb angles on the shell and inner bottom, having the scantlings given in Table 10 for a span of 4 feet. These bulb angles are to be attached to the floors by vertical angles, extending for the full depth of the floors and having the same depth as the bulb angles, but these angles need not exceed 6 inches in depth. The thickness of the vertical angles may be the same as that of the floors.

Riveting at each end of the vertical angles is to be as required by Table 8, cols. 4 and 5.

Plate Floors

507 Plate floors are to be fitted at every frame in the engine room and in the forward ·25L; they are also to be fitted under the boiler bearers, bulkheads, toes of brackets to

deep tank bulkhead stiffeners and in way of any change in depth of double bottom. Partial plate floors are to be fitted under the thrust seating.

The floors under the engine room, thrust seating and boiler bearers are to have double angles or equivalent attachments to the centre girder; elsewhere the connections may be single. The reversed frames on the floors may be single except under the engine room from the centre line to the girder outside the engine seating, under the thrust seating and from side to side under boiler bearers.

508 Except as required by 507, plate floors may be spaced not more than 10 feet apart, and the shell and inner bottom plating between these floors is to be supported by bracket floors. Alternatively a system of longitudinal framing may be adopted—*see* 517 to 523.

509 Floors are not to be flanged.

510 Watertight floors are to be fitted below or in the vicinity of watertight bulkheads and their thickness is to be ·08 inch greater than that given in Table 6, col. 10, but need not exceed ·54 inch. If the depth of the centre girder exceeds 36 inches the floors are to be fitted with stiffeners, of scantlings given in Table 9, spaced 30 inches apart; the ends of the stiffeners are to extend to the toes of the boundary angles.

511 Additional stiffening is to be fitted under the heels of widely spaced pillars as required by D 1516 to D 1523.

512 In ships from which the cargo is to be regularly discharged by grabs, it is recommended that plate floors be fitted at every frame.

Bracket Floors

513 The scantlings of the bottom frames and reversed frames are to be determined from Table 7 and associated notes.

514 The breadth of the brackets attaching the frames and the reversed frames to the centre girder and margin plate is to be three-quarters of the depth of the centre girder; the brackets are to be flanged on the unsupported edge and are to have the same thickness as the plate floors.

515 The frames and reversed frames are to be attached to the side girders by angles having the same depth as the reversed frames, but these angles need not exceed 6 inches in depth. The thickness of the vertical angles may be the same as that of the floors.

Struts, if fitted to reduce the unsupported span of the frames and reversed frames, are to have the scantlings given in Table 8. Where the struts are welded the area is to be at least 80 per cent of that given in Table 8, col. 6, provided their stability and end connections are adequate.

516 Details of riveted connections in bracket floors are given in Table 8.

Longitudinal Framing

517 Where longitudinal framing is adopted in the double bottom the scantlings of the longitudinals are to be as given in Table 10 and associated notes.

518 Plate floors are to be fitted at every frame under the main engines and the foremost shaft tunnel bearing and at alternate frames outside the engine seating or equivalent arrangements are to be provided.

Plate floors are also to be fitted under boiler bearers, bulkheads, and the toes of brackets of deep tank bulkhead stiffeners.

Elsewhere the spacing of the floors is not to exceed 12 feet or ·05L and the thickness of the floors is to be increased 10 per cent beyond that required by Table 6.

The longitudinal girders under the main machinery are to extend for the full length of the machinery space and are to be carried aft to support the foremost shaft tunnel bearing; this extension abaft the after engine room bulkhead is to be at least three transverse frame spaces. At the fore end of the engine room the girders are to be tapered off over three transverse frame spaces and are to be efficiently scarphed into the longitudinal framing system.

519 The floors are to be attached to the shell and inner bottom by double angles or equivalent for two spaces of longitudinals at each end of the floor plate. The floors are to be attached to the centre girder and margin plate by double angles single riveted, or equivalent, except where the spacing of the floors exceeds 8 feet when the attachment to the centre girder is to be by double angles double riveted.

520 The unsupported span of the longitudinals is not to exceed 8 feet. In longer spans struts of the same scantlings as required for bracket floors (Table 8) are to be introduced and attached to the longitudinals by the number of rivets given in the Table. The scantlings of the longitudinals at shell and inner bottom adjacent to the centre girder and margin plate may be based on a span of 4 feet.

The shell and inner bottom longitudinals are to be attached to the floors by means of vertical angles extending from the shell to the inner bottom having the same depth as the inner bottom longitudinals, but these angles need not exceed 6 inches in depth; they are to be riveted as required by Table 8. The thickness of the vertical angles may be the same as that of the floors.

Where longitudinals are cut at watertight floors they are to be attached to the floors by brackets of a width on each arm equal to three times the depth of the shell longitudinals, of the thickness given in Table 6, col. 10 or 11, and riveted as required by Table 8, cols. 7 and 8.

521 An intercostal side girder, as required by 503 to 505, is to be fitted on each side where B exceeds 45 feet and two side girders on each side where B exceeds 70 feet.

522 Between plate floors, transverse brackets of the thickness required by Table 6, col. 10 or 11, are to be fitted extending from the centre girder and margin plate to the adjacent longitudinal. The brackets, which are to be flanged, are to be fitted at every frame at the margin plate and those at the centre girder are to be spaced not more than 4 feet apart.

523 Where, at the ends of the ship, the longitudinal system of framing is replaced by a transverse system adequate arrangements are to be made to avoid abrupt discontinuities.

Inner Bottom Plating and Margin Plates

524 The inner bottom plating is to be of the thickness given in Table 6 and is to be increased by ·08 inch under the hatchways if no ceiling is fitted; the thickness of the middle line strake is not to be less than that of the increased inner bottom plating.

The margin plate is to have the thickness given in Table 6 and is to be of the depth amidships required by Table 6, note 2.

525 If cargo is to be regularly discharged by grabs, or similar means, it is recommended that double ceiling should be fitted or the thickness of the plating increased ·20 inch and fitted with a flush surface.

526 In passenger ships, the inner bottom plating is to be continued out to the ship's side in such a manner as to protect the bottom to the turn of bilge. Such protection will be deemed satisfactory if the line of intersection of the outer edge of the margin plate with the bilge plating is not lower at any part than a horizontal plane passing through the point of intersection with the frame line amidships of a transverse diagonal line inclined at 25 degrees to the base line and cutting it at a point one half the ship's moulded breadth from the middle line.

Manholes and Lightening Holes

527 Sufficient manholes are to be cut in the inner bottom, floors and side girders to provide adequate ventilation and access to all parts of the double bottom and the edges of the holes are to be smooth. No manholes are to be cut in the floors or girders under widely spaced pillars.

528 Where manhole covers are attached by bolts to the inner bottom plating, doubling plates or rims are to be fitted to take the fastenings of the covers. Manhole covers which project above the inner bottom plating are to be adequately protected.

Tank Side Brackets and Margin Connections

529 The height and thickness of the tank side brackets are given in Table 11. The free edges of the brackets are to be flanged or otherwise stiffened.

At the ends of the ship where the form of the brackets may become unduly elongated, the arrangements will be specially considered.

530 Riveted attachments of the tank side brackets to the frames and margin plate are given in Table 11. The angles attaching the floors to the margin plate are to have the same number of rivets in both flanges as the angle to the tank side brackets, and the inner and outer angles are to be through riveted.

If gusset plates are fitted they are to be not more than three frame spaces apart; if the number of rivets required in the gusset is more than six per frame space the gusset is to be fitted at every frame or is to be a continuous plate. Gussets are to be so spaced that each will require not less than three rivets.

531 If the margin plate is approximately horizontal the strength of the margin connection will be specially considered.

532 For increases in the panting region, *see* D 906.

Increased Thicknesses in Machinery Spaces

533 In the boiler room and donkey boiler recess the floor plates and brackets, centre and side girders, inner bottom plating, margin plate, tank side brackets, gussets and all rolled sections not covered by cement, and in the engine room the inner bottom plating, are to be increased in thickness as required in Tables 6 to 11 and associated notes.

534 Where machinery is fitted aft, the thicknesses of the inner bottom plating in the boiler room are to be increased by the increments which would have been added if the machinery had been fitted amidships; in the engine room this thickness is to be as given in Table 6, col. 18.

Strengthening of Bottom Forward

535 The bottom structure forward is to be in accordance with the requirements of D 8.

Ships Loading and Discharging Aground

536 It is recommended that the bottoms of small ships intended to load or discharge aground be additionally strengthened in order to withstand the exceptional stresses to which they may be subjected.

Oil Fuel

537 If oil fuel is to be carried in double bottoms the provisions of D 2019 and D 2020 are to be complied with.

Where refrigerated cargoes are to be carried, *see* D 2021 and D 2022.

Pumping and Drainage

538 The arrangements are to be in accordance with the requirements of Chapter E.

539 Ample provision is to be made for the free passage of air and water from all parts of the tanks to the air pipes and suctions.

Caulking and Water Testing

540 The double bottom is to be caulked and made watertight, but the centre girder need not be caulked or tested.

Each compartment on completion is to be tested with a head of water representing the maximum pressure which could be experienced in service.

Cross-reference

541 For additional stiffening under heels of pillars, *see* D 1520.

Section 6

SIDE FRAMING

Scantlings

601 The scantlings of the main, peak and 'tween deck frames are to be determined from Tables 12 and 13 and associated notes.

The depth D for use in the Tables is defined in D 203.

602 The scantlings given for the framing in the various 'tween decks represent the minimum standard, but the system is to be so arranged that continuity is maintained.

603 Where holes are drilled or punched in the inboard flange of channel or similar hold frames, the scantlings may have to be increased.

Frame Spacing

604 The spacing of the frames, except in the regions defined in 605 and 606, may be as given in Tables 12 and 13.

605 Frame spacing in peaks and cruiser sterns is not to exceed the Table spacing or 24 inches, whichever is less.

606 Frame spacing between ·2L from forward and the collision bulkhead is not to exceed the Table spacing or 27 inches, whichever is less.

607 Where the spacings adopted differ from those set forth in 604 to 606, the scantlings of the main and 'tween deck frames are to be corrected as required by the notes.

Main Framing

608 The depth h to be used in Table 12 is defined in D 205, and is to be measured :

At amidships, for framing between the after peak bulkhead and ·25L from the fore end.

At ·25L from the fore end, for framing between that point and ·15L from the fore end.

As required by D 905 for framing between ·15L from the fore end and the collision bulkhead.

Framing in 'Tween Decks and Superstructures

609 In 'tween decks marked B (*see* notes to Table 13) between ·12L from the after end and ·2L from the fore end and in detached superstructures, frames may be fitted two frame spaces apart provided the main frame spacing does not exceed 30 inches and the ratio of that spacing in inches to the minimum thickness of the 'tween deck side plating does not exceed 55 in ships 300 feet or less in length and 45 in ships 500 feet or more in length, with intermediate values in proportion.

610 At each end of a bridge four frames are to extend from the 'tween deck below to the bridge deck.

611 'Tween deck and superstructure frames are to be efficiently scarphed to the main frames below or effectively attached to the deck, except in the poop where the lower ends of the intermediate frames (if fitted) need not be attached.

Cruiser Sterns

612 Cruiser sterns are to have frames of size required in peaks, and are to be additionally stiffened by web frames where required. The floor plates are to be of a reasonable depth, and are to be associated with a middle line girder.

General

613 Floors in fore and after peaks are to have a thickness ·04 inch greater than required for floors in a double bottom. In after peaks the floors are to extend well above the stern tube, or, if this is impracticable, cross-tie plates flanged on both edges are to be fitted above the stern tube. Rivets connecting floors and cross-tie plates to the frames are to be spaced not more than five diameters apart. (*See* D 908.)

614 In boiler rooms and permanent coal bunkers the thickness of the framing is to be increased ·06 inch beyond that derived from the Tables.

615 Where the depth of the framing is reduced adequate stiffness is to be maintained.

616 The breadth of the shell flange of the frames is to be suitable for the diameter of rivet used.

Cross-references

617 For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces, *see* D 19, D 20 and D 22.

Section 7

SHELL PLATING

Scantlings

701 Scantlings of flat plate keel and of garboard strakes with a bar keel are given in Table 14.

702 The thicknesses of bottom and side shell plating are to be determined from Table 14 and associated notes. The depth D for use in the Table is defined in D 203.

703 In way of an effective superstructure the thickness of bottom and side plating may be based on D measured to superstructure deck, but clear of the superstructure D is to be taken to the uppermost continuous deck. The thicker plating is to be suitably extended within the ends of the superstructure to ensure continuity of strength. (*See* 710.)

704 The scantlings of the sheerstrake are to be in accordance with Table 18 and D 1101.

Openings in Shell Plating

705 All openings in the shell plating for cargo doors, inlets, or other purposes, are to have well rounded corners, and arrangements are to be made to maintain the strength in way of the openings; the plating is to be reinforced in way of hawse pipes.

706 Where side scuttles or other openings are cut in the sheerstrake, removing more than 20 per cent of the Rule sectional area of the unpierced plate, compensation is to be provided.

Shift of Riveted Butts

707 The butts of shell plates and those of sheerstrake and stringer plates are to be arranged to give as good a shift as practicable; in adjoining strakes butts are to be generally at least two frame spaces apart.

The butts of the sheerstrake are to be at least two frame spaces from those of adjacent deck stringer plates.

Welded Construction

708 In ships having transverse framing, if the seams and butts of the bottom shell plating are flush welded and the floor angles are riveted to the bottom shell then the thickness of the bottom plating is to be increased for ·4L amidships by 5 per cent above the requirements of Table 14 and associated notes.

If the seams and butts of bottom shell plating are flush welded and the floors are welded to the shell, the thickness of the bottom plating is to be increased for ·4L amidships by 15 per cent above the requirements of Table 14 and associated notes.

In addition to the provisions of D 503, the following stiffening is to be fitted to the bottom shell for ·4L amidships with either system of construction:—

Beam not exceeding 50 ft.	Two longitudinal stiffeners, p. & s.
Beam above 50 ft. and not exceeding 55 ft.	Four longitudinal stiffeners, p. & s.
Beam above 55 ft. and not exceeding 64 ft.	Three longitudinal stiffeners, and one intercostal side girder p. & s.

Special consideration will be given to ships having greater beam.

The stiffeners are to be $6 \times 3\frac{1}{2} \times \cdot 46$ ordinary angle toe welded to the plating and connected at their ends. The intercostal side girders are to be of scantlings given in Table 6.

This stiffening, in which the engine girder system may be incorporated, is to be suitably scarphed to the stiffening forward required by D 801 and D 805, and is to be tapered gradually at the aft end.

Wood Belting

709 Wood belting and fenders are not to be through bolted to the shell plating.

Continuity of Strength

710 Continuity of strength is to be maintained at the break of superstructures as required by D 1206 and D 1305 to D 1308.

Section 8

STRENGTHENING OF BOTTOM FORWARD

Extent

801 The bottom structure is to be strengthened between ·05L and ·25L from the fore end. A sketch showing sections in way of the bottom forward is to be submitted.

Shell Plating

802 The thickness of the three strakes next to the keel plate, or, in small ships, two strakes provided these cover the flat of bottom, is to be that given in Table 14, col. 10, increased by 30 per cent where the length of the ship does not exceed 450 feet and 15 per cent where the length is 650 feet; the increase at intermediate lengths to be in proportion. In ships with machinery aft not exceeding 300 feet in length the increase is to be 40 per cent and the keel plate is not to be less in thickness than the adjacent bottom plating.

The midship thickness of the above strakes is to be carried forward to the increased plating.

If the floors are welded directly to the bottom plating the latter is to be increased in thickness.

Double Bottoms

803 Floors and intercostal girders are not to be flanged.

804 Plate floors are to be fitted at every frame and are to be connected to the bottom plating by double angles, or equivalent connections, extending from margin to margin, or, in single bottom ships, to lower turn of bilge.

805 The intercostal side girders are not to be more than 7 feet apart, the plating between them being supported by additional half-height intercostal girders carried as far forward as practicable.

806 Where longitudinal framing is adopted in the double bottom the arrangements are to include plate floors fitted on alternate frames between ·05L and ·25L from the fore end and the spacing of longitudinal framing is to be in accordance with the requirements of D 606.

Single Bottoms

807 The reversed frames are to be doubled and additional intercostal girders are to be fitted; in other respects the requirements for double bottoms are to be carried out where they apply.

Riveting

808 The rivets in both flanges of the frame angles are to be spaced $5\frac{1}{2}$ diameters apart. The diameter of rivets in butts and seams of bottom plating is to be appropriate to the increased thickness of the plating, and the seams are to be double riveted.

Section 9

ARRANGEMENTS TO RESIST PANTING

Extent

901 The structure is to be strengthened to resist panting for ·15L from the fore end and abaft the after peak bulkhead.

Forward of the Collision Bulkhead

902 Tiers of beams spaced 6 feet apart are to be fitted to alternate frames below the lowest deck and are to have the scantlings given in Table 15.

903 Stringer plates of the scantlings given in Table 16 are to be fitted at each tier of beams. The stringer plates are to have double attachments to the shell plating. Alternatively, stringer plates of Table scantlings may be fitted inside the frames without attachment to the shell plating provided the stringer plate is stiffened on both edges, and the thickness of the shell plating is 10 per cent greater than the thickness given in Table 14, col. 9, where the length of the ship does not exceed 150 feet and 25 per cent where the length is 350 feet or above; the increase at intermediate lengths is to be in proportion.

904 Frames to which a beam is not fitted are to be attached to the stringer plate by brackets, having the same thickness as the beam knees and a depth of one-half the breadth of the stringer plate.

Abaft the Collision Bulkhead

905 The strength of the side frames below the lowest deck for the distance defined in 901 is to be increased 20 per cent above that derived from Table 12, the value of h for use in the Table being the maximum between ·15L from the fore end and the collision bulkhead, measured as defined in D 205.

906 The strength of the attachment of the frames to the tank side brackets, of the tank side brackets to the margin plates and gussets, and of the gussets to the margin plate is to be increased by 20 per cent above the requirements of Table 11. The connection of the floors to the margin plate is to be the same as the connection of the tank side brackets to the margin plate, and, where riveted, the connecting angles inside the tank are to be on the same side of the floor as the outside connections, to take through rivets.

907 Side stringers of the scantlings given in Table 16 are to be fitted in line with those forward of the collision

bulkhead and are to extend aft for the distance defined in 901; they are to be attached to the shell by single riveted angles.

The side stringers may be omitted provided the shell plating is increased by the percentage given in 903.

Abaft the After Peak Bulkhead

908 The structure is to be efficiently stiffened by deep floors and tiers of beams in association with stringers as required in the fore peak (Tables 15 and 16) except that these may be spaced 8 feet apart. In twin screw ships the frames abaft the propeller brackets and up to the lowest deck are to be attached to the shell plating by two rows of rivets or equivalent connections. (*See* D 613.)

Special arrangements may be required in single screw ships of high speed.

If, on account of the ship's form, the unsupported length of the frames exceeds 8 feet, additional stiffening may be required.

Deep 'Tween Decks

909 If necessary, in ships with deep 'tween decks additional intercostal side stringers supported by web frames are to be fitted at the forward and after ends. The stringers may be omitted provided the thickness of the shell plating is suitably increased.

Section 10

STRENGTHENING FOR NAVIGATION IN ICE

General

1001 Where owners contemplate operating the ship in the ice at a trimmed ballast waterline this is to be indicated on the plans in addition to the light waterline. All references to "light waterline" are then to be taken as applying to the "light" or "ballast" waterline whichever is the lower.

CLASS 1

Framing

1002 Intermediate frames are to be fitted over the full length of the ship. The strength of these frames is to be the same as the rule main frames unless stringers are fitted in accordance with D 1005 when the intermediate frames may be 75 per cent of the rule main frames. In the panting region and in deep tanks the modulus of the intermediate frame is to be determined from the modulus of the main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from 3 feet below the light waterline to 2 feet 6 inches above the load waterline. They are to be connected at their ends to the main frames by a horizontal member having the same scantlings as the main frames or equivalent arrangements are to be provided.

In the fore and after peaks the main and intermediate frames are to have the same modulus as the rule midship frame.

Shell Plating

1003 For a distance 2·5B abaft the forward perpendicular and extending vertically from 2 feet below the light waterline to 2 feet 6 inches above the load waterline the thickness of the shell plating is to be 50 per cent greater than the rule midship thickness.

For the remainder of the length over the same vertical extent the thickness is to be 25 per cent greater than the rule midship thickness. The change of thickness is to take place gradually.

The increased thickness need not exceed 1·00 inch but is not to be less than ·50 inch.

When the s.h.p. exceeds 0·21 (L×B) the shell plating for a distance B abaft the forward perpendicular shall be increased by 0·04 inch for each 500 h.p. excess over the above figure but need not exceed 1·00 inch. (The s.h.p. is to be indicated on the plan on which the shell plating is approved.)

Riveting

1004 The seams of increased shell plating are to be at least double riveted. The diameter of the rivets used may be $\frac{1}{8}$ inch less than that required by Table 52A for the increased thickness of plating but is not to be less than that required for the rule thickness.

Stringers

1005 The following requirements apply only when the intermediate frames are made 75 per cent of the main frames (*see* D 1002).

Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 6 feet apart for a distance 1·5B from the forward perpendicular.

The stringer next below the load waterline is to extend over the full length of the ship unless a deck is situated not more than 2 feet below the load waterline.

Rudder and Steering Arrangements

1006 The diameters of the rudder head and pintles are to be increased by 25 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 50 per cent above that required by Table 46. The gudgeons, remaining rudder items, coupling and steering gear are to be based on the increased rudder head or pintle.

In welded double plate rudders the horizontal and vertical webs are not to be welded direct to the side plates but are to be attached to flat bars or equivalent arrangements made to avoid a hard point.

The rudder head is to be protected by a suitable cruiser stern or other equivalent arrangements.

Sternframe

1007 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 25 per cent above the rule requirements.

Stem

1008 A solid stem of forged, rolled, or cast steel is to be fitted up to 2 feet 6 inches above the load waterline and the sectional area is to be 25 per cent greater than rule requirements.

Above this position a plate stem may be fitted and the thickness of plates at 2 feet 6 inches above the load waterline is to be 65 per cent greater than the rule midship thickness but need not exceed 1 inch. The thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished.

The connections of the shell plating to the stem are to be flush.

Cross-reference

1009 For machinery requirements *see* H 8.

CLASS 2

Framing

1010 Intermediate frames are to be fitted from the stem to 2·5B abaft the forward perpendicular, or to the point at which the load waterline has its greatest breadth, whichever is furthest aft. The strength of these frames is to be the same as the rule main frames unless stringers are fitted in accordance with 1013, when the intermediate frames may be 75 per cent of the rule main frames. In the panting region and in deep tanks the modulus of the intermediate frames is to be determined from the modulus of main frames before the increases required by D 905 and D 1909 are applied.

The intermediate frames are to extend from 3 feet below the light waterline to 2 feet 6 inches above the load waterline. They are to be connected at their ends to the main frames by a horizontal member having the same scantlings as the main frames or equivalent arrangements are to be provided.

In the fore and after peaks the main and intermediate frames are to have the same modulus as the rule midship frame.

Shell Plating

1011 For a distance B abaft the forward perpendicular and extending vertically from 2 feet below the light waterline to 2 feet 6 inches above the load waterline the thickness of the shell plating is to be 50 per cent greater than the rule midship thickness.

For the remainder of the length over the same vertical extent the thickness is to be 15 per cent greater than the rule midship thickness. The change of thickness is to take place gradually.

The increased thickness need not exceed 1·00 inch but is not to be less than ·50 inch.

When the s.h.p. exceeds 0·21 (L×B) the shell plating for a distance B abaft the forward perpendicular shall be increased by 0·04 inch for each 500 h.p. excess over the above figure but need not exceed 1·00 inch. (The s.h.p. is to be indicated on the plan on which the shell plating is approved).

Riveting

1012 The seams of increased shell plating are to be at least double riveted. The diameter of the rivets used may be $\frac{1}{8}$ inch less than that required by Table 52A for the increased thickness of plating but is not to be less than that required for the rule thickness.

Stringers

1013 The following requirements apply only when the intermediate frames are made 75 per cent of the main frames (*see* D 1010).

Abaft the collision bulkhead stringers of the scantlings given in Table 16 are to be fitted 6 feet apart for a distance 1·5B abaft the forward perpendicular.

The stringer next below the load waterline is to extend for a distance 2·5B abaft the forward perpendicular or to the greatest breadth of load waterline, whichever is greater, unless a deck is situated not more than 2 feet below the load waterline.

Rudder and Steering Arrangements

1014 The diameters of the rudder head and pintles are to be increased by 12·5 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 25 per cent above that required by Table 46. The gudgeons, remaining rudder items, coupling and steering gear are to be based on the increased rudder head or pintle.

In welded double plate rudders the horizontal and vertical webs are not to be welded direct to the side plates but are to be attached to flat bars or equivalent arrangements made to avoid hard points.

Sternframe

1015 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 15 per cent above rule requirements.

Stem

1016 The sectional area of a solid stem is to be 15 per cent greater than rule requirements.

Where a plate stem is fitted the thickness of plates below a position 2 feet 6 inches above the load waterline is to be 65 per cent greater than the rule midship thickness but need not exceed 1 inch. Above this position the thickness may be tapered to that of the normal plate stem (*see* D 307) at the upper deck. Plates which require to be furnaced are to have these thicknesses when finished. The spacing of the horizontal webs below the load waterline is not to exceed 3 feet.

The connections of the shell plating to the stem are to be flush.

Cross-reference

1017 For machinery requirements *see* H 8.

CLASS 3

Framing

1018 Intermediate frames of the scantlings given in Table 17 are to be fitted for a distance 1·5B abaft the forward perpendicular. They are to extend from 3 feet below the light waterline to 2 feet 6 inches above the load waterline. They need not be connected at their ends.

Shell Plating

1019 For a distance B abaft the forward perpendicular and extending vertically from 2 feet below the light waterline to 2 feet 6 inches above the load waterline the thickness of the shell plating is to be 50 per cent greater than the rule midship thickness. This increased plating is to be tapered gradually into the midship plating so that the midship thickness is reached at the point where the load waterline is at the greatest breadth.

The increased thickness need not exceed 1·00 inch but is not to be less than ·50 inch.

Riveting

1020 The seams of increased plating are to be at least double riveted. The diameter of rivets used may be $\frac{1}{8}$ inch less than that required by Table 52A for the increased thickness.

Stringers

1021 For a distance 1·5B abaft the forward perpendicular stringers of the scantlings given in Table 16 are to be fitted 6 feet apart. The stringers may be omitted provided the intermediate frames are made equal in strength to the main frames.

Rudder and Steering Arrangements

1022 The diameters of rudder head and pintles are to be increased by 7·5 per cent above that required by Tables 44 and 47. The side plating and webs of double plate rudders are to be increased by 10 per cent above that required by Table 46. The gudgeons, remaining rudder items, coupling and steering gear are to be based on the increased rudder head or pintle.

Sternframe

1023 The strength of the rudder post and solepiece and the diameter of the rudder axle (if fitted) are to be increased by 7·5 per cent above rule requirements.

Stem

1024 The sectional area of a solid stem is to be 10 per cent greater than rule requirements.

Plate stems are to comply with 1016.

The connections of the shell plating to the stem are to be flush.

Cross-reference

1025 For machinery requirements *see* H 8.

Section 11

DECKS

Plated Decks

1101 Strength deck and sheerstrake scantlings are to be determined from Table 18 and associated notes. The depth D for use in the Table is defined in D 203. Strength deck requirements are tabulated for ships having one, two or

three decks. If there is more than one deck the sectional area of the strength deck given in Table 18 is that required when the scantlings of the lower decks are in accordance with Table 20.

1102 Scantlings for effective superstructures, as defined in D 206, are also to be determined from Table 18, the depth D being measured to the superstructure deck. (*See* Table 18, note 9.)

1103 Minimum thicknesses of strength decks and lower decks are given in Tables 18 and 20 respectively.

1104 Platform decks for which no credit is taken in determining the scantlings of the strength deck (*see* 1101) are to have the scantlings given in Table 20, col. 8.

Decks with Stringer and Tie Plates

1105 The scantlings of stringers and tie plates fitted under a wood deck are to be determined from Table 18, note 10, and Table 20, note 5.

Tie plates are to be fitted at each side of the hatchways and are to be continuous; where these form the upper members of girders supported by widely spaced pillars they are to be suitably increased. Cross ties are to be arranged at the ends of hatchways and other openings. The decks are to be plated over abreast machinery openings, the plating being tapered into the stringer plates beyond the openings.

Stringer Angles

1106 The butts of strength deck stringer angles are to be efficiently welded or strapped and if the angle is cut in way of scuppers compensation is to be provided.

Concentration of Loading

1107 Additional strengthening to the decks may be required where there is indication of concentration of loading.

Continuity of Strength

1108 Continuity of strength is to be maintained at the ends of large openings in the strength deck and the deck below by means of corner doubling plates or equivalent arrangements, and associated, if necessary, with intercostal girders at the strength deck. Special attention is to be given to workmanship at these parts.

For welded construction, *see* D 3106.

Wood Sheathing and Decks

1109 The material is to be of good quality, well seasoned and free from sapwood. The thickness is to be not less than $2\frac{1}{2}$ inches for pine or 2 inches for teak.

Thwartship planks are to be laid at the ends of hatchways, deckhouses and similar boundaries.

The vertical flange of coaming or foundation angles is to extend $\frac{1}{2}$ inch above the wood deck. Gutterway angles or welded flats are to be not less than ·30 inch in thickness.

The planking is to be efficiently fitted. Fastenings are to be not less than $\frac{1}{2}$ inch in diameter, sunk below the surface of the planking and covered with turned dowels, the whole being thoroughly bedded in white lead or other suitable composition.

Bolts are to be galvanised; welded studs used instead of bolts are to be coated with suitable composition before the planking is laid.

All decks are to be caulked and payed.

Deck Compositions

1110 If an approved composition is laid as a substitute for wood sheathing the steel deck is to be caulked, made watertight and coated with a suitable material in order to prevent corrosive action between the steel and the composition. The composition is to be effectively secured to the deck.

Caulking and Water Testing

1111 All plated decks are to be caulked unless sheathed with a properly caulked wood deck. The spaces between frames at lower decks are to be effectively closed by cement or other means.

Weather decks and gutterways are to be hose tested on completion.

Section 12

DETACHED SUPERSTRUCTURES

Forecastles

1201 All seagoing ships are to have forecastles except where the load draught is less than ·7D. Where the omission of the forecastle may be necessary, increased sheer forward is to be provided as may be required by the Committee.

Short Superstructures

1202 The scantlings of poops and forecastles, and of bridges not exceeding ·15L in length, are to be determined from Table 21 and associated notes.

All seams and butts may be single riveted.

Long Bridges

1203 A long bridge is an effective superstructure as defined in D 206, and the scantlings are to be determined from Table 18 and associated notes. (*See* D 703 and D 1102.)

Second and third deck scantlings may be reduced in way of the superstructure. (*See* Table 18, note 9.)

1204 The riveting of butts and seams of deck plating, sheerstrake and side plating is to be as required by Table 52 B & C, but the side plating and sheerstrake seams are not to be less than double riveted for four frame spaces at the ends of the superstructure.

1205 Transverse strength is to be ensured by fitting web frames or partial bulkheads in the bridge if large deckhouses are constructed above.

Strengthening at Ends of Superstructures

1206 The thickness of the upper deck sheerstrake is to be increased by 50 per cent and the thickness of the stringer plate by 25 per cent at the ends of long bridges. Similar strengthening is to be fitted at the ends of poops or forecastles within ·5L amidships.

At the ends of short bridges these increases are to be 30 per cent and 10 per cent respectively.

In way of a long bridge the upper deck sheerstrake, stringer plate and deck plating as fitted in the wells are to extend into the bridge for a distance equal to about one-third the breadth of the ship.

The bridge side strakes, which are to be increased 25 per cent in thickness at the ends of the superstructure, are to be tapered as far as practicable into the bulwark plating or upper deck sheerstrake; the plating is to be efficiently stiffened at its upper edge and supported by web plates not more than 5 feet from the end bulkhead.

Bulkheads at Ends of Superstructures

1207 The bulkheads at the ends of poops, bridges, and forecastles are to have the scantlings and arrangements given in Table 22 and associated notes.

Deckhouses

1208 All deckhouses are to be of sufficient strength and the scantlings of the ends, sides and of the top beams are to be in accordance with the requirements of Table 23 and associated notes. Beams and stiffeners should, as far as possible, be fitted in line with the main framing.

1209 Where the length of single or two-tier deckhouses exceeds ·15L, the sectional area of the top plating is to be derived from Table 23 and associated notes. In all ships above 300 feet in length the exposed decks over passenger accommodation are to be completely plated.

1210 The sides and ends of the deckhouses are to be supported by partial bulkheads or web frames, spaced about 30 feet apart, and web frames are to be fitted, if practicable, at the sides of large openings.

Arrangements are to be made to minimise the effect of discontinuities in the deckhouse structure. All openings cut in the sides should be substantially framed and have the corners well rounded; continuous coamings are to be fitted below and above doors and similar openings.

Particular attention is to be given to the structure at the corners and ends of long deckhouses. Adequate support under the ends of the houses is to be provided in the form of web frames at ship's sides and diaphragms or pillars near the centreline in conjunction with reinforced deck beams. The corners of the deckhouses should be connected to the deck by double riveted or equivalent connections, which, if incorporating welding, will be specially considered.

The deckhouse sides are to be additionally stiffened in way of boats and the top strengthened in way of the davits.

1211 Partial bulkheads or web frames are to be fitted in the 'tween decks below deckhouses and, where practicable, in continuation of watertight bulkheads below.

Cross-reference

1212 For exposed casings protecting machinery openings, *see* D 22 and Table 23, note 11.

For scantlings of deck plating inside long deckhouses *see* Table 18, note 2 (*d*).

Section 13

RAISED QUARTER DECKS

Scantlings in way of the Raised Quarter Deck

1301 The scantlings of shell, sheerstrake, stringer and deck plating are to be based on the depth D measured to the raised quarter deck.

1302 The scantlings of side frames are to be based on the depth D measured to the upper deck with h measured to the raised quarter deck.

1303 The scantlings of beams are to be determined using the depth D measured to the raised quarter deck.

Break Bulkhead

1304 The front or break bulkhead of the raised quarter deck is to have the thickness of plating required for bridge front bulkheads and is to be sufficiently stiffened.

Strengthening at Break

1305 The stringer plates of the upper or bridge deck and the raised quarter deck are to overlap for three or four frame spaces at either side of the break bulkhead according to the size and proportions of the ship.

1306 Similarly in ships exceeding 220 feet in length the deck plating is to overlap for two or three spaces and the stringers are to extend for two or three spaces beyond the plating.

1307 Sufficient diaphragm plates, of the thickness of the break bulkhead, are to be fitted between the overlapped decks and connected to them and to the break bulkhead by double angles; the diaphragms are to be stiffened on their after edges and elsewhere if necessary.

1308 The upper deck sheerstrake is to be increased in thickness by 40 per cent and extended for a reasonable distance abaft the break. The raised quarter deck sheerstrake is also to be increased in thickness by 30 per cent when connected to a long bridge and is to be extended into the bridge.

Section 14

BEAMS AND DECK LONGITUDINALS

Scantlings

1401 The scantlings of deck beams at weather, cargo and accommodation decks are to be determined from Tables 24 and 25 and associated notes.

1402 The scantlings of deck longitudinals are to be determined from Tables 26 and 27 and associated notes.

General

1403 Beams are to be fitted at every frame.

1404 Where hatch side coamings are more than 18 inches from the deck girder the overhanging beams are to be reinforced, or the coamings are to be made sufficiently strong to act as girders to carry the ends of the beams and the load on the hatchway.

1405 Beams or longitudinals at the crown of deep tanks, peak tanks and oil fuel tanks are to satisfy the requirements of Tables 24, 25, 26 or 27 and associated notes but are not to be less in strength than the standard required for the stiffeners of the boundary bulkheads to those tanks. (*See* D 1901 and D 2004.)

1406 Where holes are punched in the face flange of channel or similar beams the modulus of the beams may require to be increased.

1407 Weather decks are to be suitably cambered.

Timber Deck Cargoes

1408 Where timber load lines are to be assigned the scantlings of deck beams at weather decks are to be in accordance with Table 24, note 6.

Beam Knees and Brackets of Deck Longitudinals

1409 The scantlings of beam knees and brackets of deck longitudinals together with their riveted attachments are to be determined from Table 28.

1410 Where intermediate frames in the 'tween decks are omitted the beam knees are to be attached to the shell plates by angles having the same thickness as the knees.

1411 In ships having more than three tiers of beams and where large areas of deck are arranged for accommodation, or where particular conditions of loading are contemplated, the requirements for beam knees will be specially considered.

1412 The riveted attachment of half beams to hatch side coamings and casings is given in Table 52 H.

Cross-references

1413 For strong hatch end beams and deck transverses, *see* D 1512 to D 1515.

For strengthening in machinery spaces, *see* D 2207.

Section 15

DECK GIRDERS AND PILLARS

General

1501 Deck beams are to be supported by longitudinal deck girders in association with pillars or strong hatch end beams.

Deck longitudinals are to be supported between bulkheads by transverses pillared as necessary.

For the forward ·075L of forecastle and weather decks, longitudinal girders are not to be spaced more than 12 feet apart, and transverses not more than 8 feet apart. Girders are to have intercostal plates attached to the deck and are not to consist of angle runners.

Pillars in the 'tween decks and holds are to be in the same vertical line, as far as practicable.

The scantlings are to be determined from Tables 29, 30 and 31 and associated notes.

Special Loads

1502 Where a girder is subject to concentrated loads, such as pillars out of line, the scantlings are to be suitably increased and the pillars which support the girder are to be strengthened to bear the portion of the concentrated load which they carry.

1503 Where cargoes such as chilled meat are suspended from a deck which may be simultaneously loaded above, the scantlings of the girders are to be increased as required by Table 29, note 1 (*f*).

1504 Additional attachments may be required to meet particular local stresses.

Longitudinal Deck Girders

1505 Girders are to be connected to the deck by angles of the same thickness as the web plate. If the span is greater than 30 feet in association with a normal height of 'tween deck, the deck connection is to be doubled for two beam spaces at each end.

1506 Girders of unsymmetrical section are to be supported by tripping brackets at alternate beams; if the section is symmetrical the brackets may be four frame spaces apart. Where the unsupported width of the girder flanges is 6 inches or greater the tripping brackets are to be connected to the face bar or flange. Where symmetrical sections are fitted tripping brackets are to be fitted on both sides. Intermediate beams are to be connected to the girders by lugs having the same thickness as the web plate and extending to the toe of the face bar or to the flange.

The thickness of deck plating in way of the girder is to be increased where necessary to provide an effective upper flange of the girder.

1507 Girders are to be attached to the bulkhead by flanged brackets of the same thickness as the girder. The distance of the toe of the bracket below the deck is given in Table 29 and the horizontal arm is to be the same as the depth below the girder. The connections of the bracket to the girder and the bulkhead are to be double riveted.

1508 Continuity is to be efficiently maintained over the heads of pillars, and the butts of longitudinal material in the girders are to be efficiently strapped or welded.

Hatch Coamings

1509 At lower decks side coamings acting as girders and not forming part of a continuous girder are to be extended for at least two frame spaces beyond the hatch end beams by short girders below the deck.

1510 At weather decks deep hatch coamings which are intended to act as girders are to be extended beyond the hatchway ends in the form of brackets, the coamings below the deck being effectively connected to the hatch end beams. Where extension above the deck is not practicable the coaming below the deck is to be extended by short girders for at least two frame spaces beyond the hatch end beams.

For welded construction, *see* D 3106.

1511 At the corners of all hatchways supported by hatch end beams horizontal gusset plates are to be fitted connecting the side coamings to the hatch end beams, and the vertical connections are to be double riveted or equivalent.

Strong Hatch End Beams

1512 Strong hatch end beams are to be supported at the centre line and attached to the side frames by brackets equivalent to the requirements of Table 29, and the frames are also to be strengthened if considered necessary.

1513 The hatch end beams are to be connected to the deck plating by angles of the same thickness as the web plate and sufficient tripping brackets are to be fitted.

Deck Transverses

1514 Transverses supporting deck longitudinals are to be attached to the frames by brackets equivalent to the requirements of Table 29, and tripping brackets are to be fitted as required. The transverses are to be connected to the deck by angles of the same thickness as the web plates.

1515 Longitudinals are to be attached to the transverses by lugs having the same thickness as the web plates and extending to the toe of the face bar.

Pillars

1516 Effective arrangements are to be made to distribute the loads at the heads and heels of all pillars.

1517 Solid pillars may be attached to continuous runners, having scantlings given in Table 30, fitted under the deck beams. The runners are to be attached to each beam and to the bulkheads by angle lugs having two rivets in each flange. The heads and heels of the pillars are to have a bearing fit. At watertight and oiltight surfaces the heels are to be riveted to double angles or T bars or directly welded.

1518 Tubular pillars are to be attached at their heads to suitable capital plates supported by brackets, flanged where necessary, in order to transmit the load effectively.

Doubling plates are to be fitted to the inner bottom under the heels of tubular pillars, and to decks under pillars of large diameter. The pillars are to have a bearing fit and are to be attached to the capital and doubling plates by riveted angle rings or by continuous welding.

1519 At the heads and heels of pillars built of rolled sections the load is to be well distributed by means of longitudinal and transverse brackets.

1520 In double bottoms under widely spaced pillars the connections of the floors to the intercostal girders and of the floors and girders to the inner bottom are to be suitably increased. Where pillars are not directly above the intersection of plate floors and intercostal girders, partial floors and intercostals are to be fitted as necessary to support the pillars. Manholes are not to be cut in the floors and girders below the heels of pillars.

Where longitudinal framing is adopted in the double bottom equivalent stiffening under the heels of pillars is to be provided.

1521 In ships carrying refrigerated cargoes and carrying oil fuel in the double bottom, the connections of the hold pillars to the inner bottom, including the doubling plates, are to be welded. (*See* D 2021.)

1522 Where the heels of pillars are carried on a tunnel suitable arrangements are to be made to support the load.

1523 Where pillars are fitted under watertight flats the end attachments are to be sufficient to withstand the load due to water pressure.

1524 Additional pillars are to be fitted below deckhouses, windlasses, winches, capstans and elsewhere where considered necessary. The structure in way of the boat davits is to be strengthened.

1525 Arrangements for supporting the structure in machinery spaces will be specially considered.

Timber Deck Cargoes

1526 Where timber load lines are to be assigned the scantlings of weather deck longitudinal girders, strong hatch end beams, deck transverses and pillars are to be in accordance with Table 29, note 6 and Table 31, note 6. Particular attention is to be paid to the end connections of girders and hatch end beams. (*See also* D 1408.)

Cross-references

1527 For centre line and bunker bulkheads supporting decks, *see* D 18.

For riveting, *see* Tables 31 and 52 H.

Section 16

WATERTIGHT BULKHEADS

Number and Disposition of Transverse Bulkheads

1601 All ships are to have a collision bulkhead, situated not less than ·05L from the fore end of the load waterline, an after peak bulkhead enclosing the stern tubes in a watertight compartment and a bulkhead at each end of the machinery space.

When a coal cross bunker is situated at the forward end of the boiler space, its after bulkhead may be of non-watertight construction as required by D 18, provided the forward bulkhead complies with the requirements of this Section for watertight bulkheads.

If this compartment is to be used for cargo, the after bulkhead is to be welded or riveted and caulked as required by this Section, and all openings are to be blanked off and made watertight. The requirements of D 29 are to be complied with, and bilge suctions and sounding pipes fitted as required for a separate hold compartment.

1602 In ships exceeding 220 feet in length, additional watertight bulkheads are to be fitted so that the total number of bulkheads is in accordance with the following Table:—

Length L		Total number of bulkheads	
Above	Not exceeding	Machinery amidships	Machinery* aft
feet	feet		
—	220	4	3
220	285	4	4
285	335	5	5
335	370	6	5
370	405	6	6
405	470	7	6
470	540	8	7
540	610	9	8

* After peak bulkhead forming the after boundary of the machinery space.

1603 The bulkheads in the holds should be spaced at reasonably uniform intervals. Where this is departed from and the length of a hold is unusually great, the transverse strength of the ship is to be maintained.

1604 The Committee will be prepared to consider proposals from owners to dispense with one or more of these bulkheads if they interfere with the requirements of a special trade, subject to suitable structural compensation.

Height of Bulkheads

1605 The collision bulkhead is to extend to the uppermost continuous deck.

1606 The after peak bulkhead may terminate at the first deck above the load waterline provided this deck is made watertight to the stern or to a watertight transom floor.

1607 The remaining bulkheads are to extend to the uppermost continuous deck except where the draught is not greater than that permitted with a superstructure extending for the full length of the ship above the second deck, when the bulkheads may terminate at that deck provided it lies above the load waterline.

In passenger ships of restricted draught the height of the bulkheads will be specially considered.

Bulkhead Plating

1608 The thickness of bulkhead plating is to be in accordance with Table 32 and associated notes.

1609 The lowest strake is to be at least 36 inches deep measured from the inner bottom, or from the keel if there is no double bottom; where an inner bottom terminates on a bulkhead the top of the lowest strake of the bulkhead is to be at least 12 inches above the inner bottom. At stokehold bulkheads in coal burning ships the lowest strake is to extend at least 24 inches above the stokehold platform.

Bulkhead Stiffeners

1610 The scantlings of vertical stiffeners having bracketed or lugged end connections are to be determined from Table 33 or 34 respectively, and associated notes. The scantlings of stiffeners which are bracketed at one end and lugged at the other may be taken as a mean between those required by Tables 33 and 34.

The scantlings for stiffeners in tugs are given in Table 35.

1611 The Tables apply to stiffeners spaced 24 inches apart at collision bulkheads and 30 inches apart at other watertight bulkheads not forming boundaries of tanks. Scantlings are to be corrected as required by the notes for departures from Table spacing.

1612 Where bulkhead stiffeners are cut in way of watertight doors in the lower part of a bulkhead the opening is to be suitably framed, and a tapered web plate, stiffened on its edge, is to be fitted on each side of the door from the base of the bulkhead to well above the opening.

Where stiffeners are not cut but the spacing between the stiffeners is increased on account of watertight doors, as in 'tween deck bulkheads, the stiffeners at the sides of the doorways are to be increased in depth and strength so that the efficiency is at least equal to that of the unpierced bulkhead, without taking the stiffness of the door frame into consideration.

1613 Bulkheads are to be suitably strengthened if necessary at the ends of deck girders and where subjected to concentrated loads.

End Attachments of Stiffeners

1614 End brackets for stiffeners derived from Table 33 are to have dimensions, measured from the heel of the boundary angle to the toes of the bracket, equal to two and a half times the depth of the stiffener. The thickness of the brackets and the number of rivets required are given in Table 36.

The bracket or its connecting angle at the lower end of each stiffener is to extend to the floor adjacent to the bulkhead.

At each deck level which forms the top of a system of stiffeners plating is to be provided of a character which will ensure rigidity, and the attachments of the upper brackets on the hold stiffeners to this plating are to extend over a beam space.

Where the inner bottom is framed longitudinally the stiffeners of the bulkhead should be arranged, if practicable, over the longitudinals.

1615 End lugs for stiffeners derived from Table 34 are to be of the same thickness as the boundary angles and are to be riveted as required by Table 36.

Boundary Connections

1616 Angles connecting bulkheads to shell, inner bottom and deck plating are to be ·10 inch thicker than the Table thickness of the bulkhead plating to which they are attached.

Watertight Recesses and Flats

1617 Watertight recesses in bulkheads are to be so framed and stiffened as to provide strength and stiffness equivalent to the requirements for watertight bulkheads.

1618 Horizontal plating is to be ·04 inch thicker than required by Table 32 for watertight bulkheads at corresponding levels. The strength and stiffness of beams are to be equivalent to the requirements of Table 33 if cut and bracketed or continuous.

The thickness of plating and scantlings of beams are not to be less than required by D 11 and D 14.

Longitudinal Bulkheads

1619 Watertight longitudinal bulkheads are to be equal in strength and stiffness to the requirements for transverse bulkheads.

Chain Lockers

1620 Chain lockers fitted abaft the collision bulkhead are to be caulked and the space is to be efficiently drained.

Riveting

1621 Requirements for riveting are given in Table 52 H.

Welded Stiffeners

1622 The scantlings of welded stiffeners will be considered in accordance with note 3 to Tables 33 to 36.

Watertight Doors

1623 Watertight doors are to be efficiently constructed and fitted, tried under working conditions and hose tested in place.

Provision should be made to ensure that coal will not impede the satisfactory operation of bunker doors.

1624 Watertight doors are to be capable of being quickly closed from an accessible position above the bulkhead deck, and are to have an index at the operating position showing whether the door is open or closed. Hand gear is to have an all-round motion. The lead of shafting is to be as direct as possible and the screw is to work in a gunmetal nut.

1625 Hinged watertight doors of approved pattern may be fitted in 'tween decks in approved positions. The hinges of these doors are to be fitted with gunmetal pins.

Caulking and Testing

1626 Watertight bulkheads, including recesses and flats, are to be caulked and hose tested on completion. At watertight flats the side frames if continuous are to be suitably collared, alternatively they may be cut and bracketed or otherwise effectively connected to the flat.

Peak bulkheads not forming boundaries of tanks are to be tested by filling the peaks with water to the level of the load waterline.

Cross-references

1627 For deep tanks, peak tanks and oil fuel bunkers, *see* D 19 and D 20.

For watertight tunnels, *see* D 17.

For machinery casings in 'tween decks, *see* D 2214.

Section 17

WATERTIGHT TUNNELS

Tunnels

1701 Where machinery is amidships the shafting is to be enclosed in a watertight tunnel large enough to permit of proper examination and repair of the shafting. A watertight door is to be provided at the forward end of the tunnel. Pipe tunnels are to have dimensions adequate for reasonable access.

Plating

1702 The thickness of plating on flat sides and curved tops of tunnels is to be determined from Table 37 and associated notes.

If the top of the tunnel is flat the plating is to be as required by D 1618 for horizontal flats of watertight bulkheads.

1703 Under hatchways the top plating is to be increased by ·10 inch, unless covered with wood not less than 2 inches in thickness which is to be secured without through fastenings in the plating.

Stiffeners and End Attachments

1704 The scantlings of stiffeners are to be determined from Table 38 and associated notes.

For flat tunnel tops the scantlings of stiffeners are not to be less than required by D 1618 for flats of watertight bulkheads.

The stiffeners are to overlap and be connected to the tunnel base angle. Angle stiffeners 6 inches in depth and all bulb angle stiffeners are to be attached to the inner bottom by lugs riveted as required by Table 36. Where welded construction is adopted equivalent arrangements are to be made.

Boundary Angles

1705 The thickness of all boundary angles is to be ·10 inch greater than the Table thickness of curved top plating given in Table 37.

Recesses

1706 The scantlings of plating and stiffeners for thrust and other recesses are to be determined as required by D 1617 and D 1618 for watertight bulkheads.

Tunnels in Deep Tanks

1707 When tunnels and recesses form boundaries of deep tanks the requirements of D 19 or D 20 are also to be complied with.

Local Strengthening

1708 Additional strengthening is to be fitted under the heels of pillars, hatch end supports or masts stepped on the tunnel. The strength of bulkheads in way of watertight doors is to be maintained as required by D 1612.

Ventilators

1709 Tunnel ventilators are to have scantlings suitable for the pressure to which they may be subjected and are to be made watertight.

Riveting, Caulking and Testing

1710 Riveting and caulking are to be as required by D 1621 and D 1626 for watertight bulkheads.

Tunnels are to be hose tested on completion.

Section 18

NON-WATERTIGHT BULKHEADS

Centre Line Bulkheads

1801 The thickness of bulkhead plating in ships exceeding 150 feet in length is to be ·30 inch in holds and ·26 inch in 'tween decks.

1802 Riveted connections of bulkheads to the decks and inner bottom are to be by single angles ·36 inch in thickness, but the attachments to the inner bottom are to be double riveted for two frame spaces at the ends of the hatchways; welded connections are to be of equivalent strength.

1803 The scantlings of stiffeners are to be determined from Table 39 and associated notes. The stiffeners may be spaced two frame spaces apart provided the frame spacing does not exceed 30 inches.

1804 Hold stiffeners are to be attached to the inner bottom by double riveted lugs or welded at their lower ends. Stiffeners at the ends of hatchways, both in holds and 'tween decks, are to have flanged brackets at top and bottom, or equivalent arrangements. Deck beams are to be connected to the stiffeners or plating of the bulkhead.

Coal Bunker Bulkheads

1805 The thickness of plating is to be as required by 1801, but the thickness of the lowest strake is to be ·36 inch; this strake is to extend at least 24 inches above the stokehold platform. Boundary angles are to be ·36 inch in thickness at the top and sides and ·40 inch at the bottom.

1806 The scantlings of stiffeners of longitudinal bulkheads which support the deck are to be as required by 1803.

1807 The scantlings of stiffeners of transverse bulkheads and of longitudinal bulkheads not supporting the deck are to be as required by Table 39, note 4.

1808 At sloping bunker casings the scantlings of stiffeners are to be suitably increased or the stiffeners are to be additionally supported by angle stays from the deck beams.

For non-watertight bulkheads at after end of cross bunkers, *see* D 1601.

Section 19

DEEP TANKS AND PEAK TANKS

Bulkheads

1901 The scantlings of plating and stiffeners of boundary bulkheads are to be determined from Tables 32 and 40 respectively, and associated notes. The plating is not to be less in thickness than ·30 inch in ships exceeding 150 feet in length. Stiffeners are to have bracketed attachments as required by D 1614.

1902 Boundary angles are to be ·10 inch thicker than the Table thickness of the bulkhead plating to which they are attached.

1903 The maximum head to which the tank will be subjected is to be shown on the plans submitted for approval.

1904 For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

Decks

1905 The thickness of plating of a deck forming the crown of a tank is to be ·04 inch greater than that which would be required by Table 32 for plating at the same depth, corrected, if necessary, for spacing, but is to be not less than ·32 inch with beams or longitudinals spaced 24 inches apart and ·40 inch where the spacing is 36 inches, with proportionate thickness for intermediate spacing; the plating is also to satisfy the requirements of D 11.

1906 Beams are to be equivalent in strength to the stiffeners of boundary bulkheads, but are also to satisfy the requirements of D 14.

1907 Beams in deep tanks are to be supported by quarter girders, the scantlings of which are to be determined from Table 41 and associated notes but are not to be less than would be required by D 15.

1908 Pillars supporting the deck girders are to satisfy the requirements of D 1516 to D 1524.

Side Frames

1909 The modulus of side frames in deep tanks is to be increased by 15 per cent beyond the requirements of D 6.

Where the frame spacing exceeds the frame spacing in Table 12 by 3 inches or more special consideration will be given to this framing.

Tunnels and Recesses

1910 The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally are to be equivalent to the requirements for boundary bulkheads.

Centre Line Bulkheads

1911 Where a complete centre line division is fitted in deep tanks the arrangements are to be as required by D 2015 and D 2016.

Ventilators

1912 Ventilators from deep tanks passing through a 'tween deck are to be strong enough to withstand the pressure to which they may be subjected and they are to be made watertight.

Riveted Connections

1913 Riveted connections are to be in accordance with the requirements of Table 52 H.

Testing

1914 Tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected, but not less than 8 feet above the crown of the tanks where the depth D (as defined in D 203) exceeds 16 feet, reduced to 3 feet where D is 10 feet or less.

General

1915 When boundary bulkheads of tanks form part of the watertight subdivision of the ship the requirements of D 16 are also to be satisfied.

1916 Tanks intended to carry oil fuel or liquid cargoes are to comply with the requirements of D 20 or D 21.

Cross-references

1917 For air and sounding pipes, *see* D 24.

For pumping and piping arrangements, *see* Chapter E.

Section 20

DEEP TANKS AND DOUBLE BOTTOM TANKS CARRYING OIL FUEL FOR SHIP'S USE

Flash Point

2001 The following requirements apply to the construction of compartments for the carriage, for ship's use, of oil fuel the close test flash point of which, as determined by a standard type of flash point apparatus, is above 150°F.

2002 When the requirements of the Rules have been complied with a notation will be made in the Register Book, except for motorships, as follows: OF (with date).

Boundary Bulkheads

2003 The thickness of plating is to be determined from Table 32 and associated notes; the plating is not to be less than ·30 inch in thickness in ships exceeding 150 feet in length.

2004 The scantlings of stiffeners are to be determined from Table 40 and associated notes. The ends of the stiffeners are to be attached by brackets in accordance with D 1614. The stiffeners are to be supported, if necessary, by horizontal girders as required by 2006 to 2009.

2005 For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

Horizontal Girders

2006 Bulkhead stiffeners and side frames are to be supported by horizontal girders, spaced not more than 10 feet apart, having scantlings determined from Table 41 and associated notes.

2007 The girders on bulkheads and ship's sides are to form a continuous line of support. They are to be connected at their ends by flanged brackets, having the same thickness as the web plate of the thicker girder and a length of arm, measured from the point of the bracket to the edge of the girder, equal to the width of the wider girder. If the bracket terminates on a bulkhead the length of the arms is to be equal to the width of the girder. All girders and brackets are to be double riveted or to have equivalent welded connections and the ends of the brackets are to be adequately supported.

2008 Riveted connections of girder plates to the bulkheads or shell plating are to be double for about twice the width of the girder at each end and may be single elsewhere.

2009 The girders are to be supported by tripping brackets at the toes of the end brackets and elsewhere at every third stiffener or frame. Stiffeners or frames intermediate between these brackets are to be effectively connected to the girders.

2010 For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

Side Frames

2011 The scantlings of side frames are to be as required by D 6, the framing depth h being measured without reference to the horizontal side girders, but the modulus may be reduced by 10 per cent where one girder is fitted or by 20 per cent where there are two girders. Where a horizontal girder is not required the modulus of the framing is to be increased in accordance with D 1909.

Decks

2012 The scantlings of decks forming the crowns of oil fuel tanks are to comply with the requirements for deep tanks given in D 1905 to D 1908.

2013 Where a steel deck abuts on an oil bunker bulkhead the deck plating is to be attached to the bulkhead either by double angles, single riveted, by a T bar, or by an equivalent welded connection. If the deck acts as a girder supporting the bulkhead stiffeners the panel of deck plating adjoining the bulkhead may require to be stiffened for this purpose.

Tunnels and Recesses

2014 The scantlings and arrangements of tunnels, horizontal and longitudinal steps, and recesses generally, are to be equivalent to the requirements for boundary bulkheads.

Centre Line Bulkheads

2015 Deep tanks which extend from side to side of the ship are to have a centre line bulkhead and quarter girders.

2016 Centre line bulkheads may be intact or perforated as desired. If intact, the scantlings and arrangements are to be as required for boundary bulkheads by 2003 to 2005.

If perforated, the modulus of the stiffeners may be 50 per cent of that required for boundary bulkheads by D 19, using H measured to the crown of the tank. The stiffeners are to be bracketed at top and bottom. The area of perforations is to be not less than 5 per cent nor more than 10 per cent of the total area of the bulkhead.

When brackets from horizontal girders on the boundary bulkheads abut on the centre line bulkhead a light intercostal stringer is to be fitted at that level for the full length of the tank, or equivalent arrangements are to be provided.

Ventilators

2017 Ventilators from deep tanks, passing through a 'tween deck, are to be strong enough to withstand the pressure to which they may be subjected and they are to be made oiltight.

Watertight Subdivision

2018 When the bulkheads of oil fuel bunkers form part of the watertight subdivision of the ship, they are also to comply with the requirements of D 16.

Double Bottom Tanks

2019 Holes are not to be cut in the centre girder except in the forward and after tanks, and elsewhere where tanks are narrow due to subdivision. The centre girder need not be caulked or tested.

2020 The inner bottom plating in cargo holds where there is no ceiling is to be not less in thickness than ·34 inch when the spacing of frames or longitudinals is 24 inches and ·40 inch when the spacing is 30 inches, with proportionate thicknesses for intermediate spacing.

Seams and end laps of inner bottom plating in the engine and boiler spaces, and in the holds where ceiling is not fitted over the whole inner bottom, are to be at least double riveted.

Special Requirements for Refrigerated Ships

2021 Where the hold above a double bottom tank carrying oil fuel is used for refrigerated cargo the tank side brackets and floor plates are to be attached to the margin plate by T bars, or by welding, and gussets are to be welded to the margin plate. The connections of hold pillars, including heel doubling plates, also of the floors and intercostal plates under the pillars to the inner bottom, are to be welded. The attachments of manhole covers are not to pass through the inner bottom plating.

2022 For the requirements for protection of oiltight bulkheads, decks and inner bottom in way of refrigerated holds, *see* E 345 and E 346.

Protection and Drainage

2023 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

2024 Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

2025 Where a bulkhead including its boundary connections is wholly welded, the requirements of 2024 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

2026 Ceiling on the inner bottom, if fitted, is to be laid on battens not less than $\frac{1}{2}$ inch in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

2027 Drip trays or gutterways with suitable draining arrangements are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded, when the drip trays need only be fitted over the boilers.

2028 If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Riveted Connections

2029 Riveted connections are to be in accordance with the requirements of Table 52 H.

Testing

2030 All oil tanks are to be tested by a head of water equal to the maximum to which the tank may be subjected but not less than 8 feet above the crown of the tank where the depth D (as defined in D 203) exceeds 16 feet, reduced to 3 feet where D is 10 feet or less. The attachment of fittings to oiltight surfaces should be completed before the tanks are tested.

Workmanship

2031 The workmanship throughout is to be of the highest character and is to be submitted to close inspection. (*See* D 31 and D 32.)

Cross-reference

2032 For air and sounding pipes and the arrangements and requirements for the use of oil fuel, *see* Chapter E.

Section 21

DEEP TANKS AND PEAK TANKS CARRYING OIL AS CARGO

Oil Fuel

2101 Oil fuel having a flash point above 150° F. may be carried as cargo in deep tanks or peak tanks providing the scantlings and arrangements of the tanks are in accordance with the requirements of D 20 for oil fuel bunkers, except that the riveting may be as required for deep tanks by Table 52 H and the centre line bulkhead need not be fitted; if, however, the tanks are intended to be partially filled only, the requirements of D 20 are to be complied with in all respects.

2102 When these requirements have been carried out a notation will be made in the Register Book as follows: "Deep tanks and (or) peak tanks—oil F.P. above 150°F.".

Vegetable and Similar Oils

2103 Vegetable oil, or similar oils, may be carried in deep or peak tanks constructed in accordance with the requirements of D 19 for ballast tanks, with the addition of a centre line bulkhead as required by D 2015 and D 2016, provided that the ventilation, drainage and control generally are as required for oil fuel bunkers.

2104 Tanks are to be designed and constructed with a view to their being cleaned with reasonable facility.

2105 Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water by a cofferdam.

2106 When these requirements have been complied with a notation will be made in the Register Book as follows: "Deep tanks and (or) peak tanks—vegetable oil".

2107 Vegetable oil may also be carried in tanks complying with the requirements of 2101 and if desired the notation may be as follows: "Deep tanks and (or) peak tanks—oil F.P. above 150° F. or vegetable oil".

2108 Where tanks are intended for other liquid cargoes of a special nature the scantlings and arrangements will be considered in relation to the density and nature of the cargo and an appropriate notation will be made in the Register Book.

Loading Certificates

2109 When a loading certificate is requested, before a cargo of oil is loaded the tank should be tested under pressure and examined for cleanness to ensure that it is in a proper condition to receive the oil cargo.

In special circumstances the Committee will be prepared, with the consent of all interested parties, to consider alternative arrangements in respect of the testing of these tanks.

Cross-reference

2110 For protection of oiltight bulkheads and decks in way of refrigerated holds, *see* E 345 and E 346.

Section 22

MACHINERY SPACES

Engine Seatings

2201 Built-up engine seatings are to be of ample scantlings and efficiently supported by brackets both longitudinally and transversely. The transverse brackets should be fitted over the floors and, as far as practicable, the longitudinal girders in the bottom are to be under those in the seating.

2202 If engines are bolted directly to the inner bottom the thickness of the plating under the engines is to be suitably increased.

The plating under the foremost shaft tunnel bearing is also to be increased in thickness and is to be scarphed in to the heavy plating under the engine bedplate.

2203 In ships having a single bottom in the engine space, the floors are to be increased in depth (*see* D 403) and the engines are to be seated on plating of substantial thickness.

2204 Additional full depth fore and aft girders are to be fitted under the engines and thrust block seatings. (*See* D 416, D 504 and D 505.)

2205 If engines are of relatively high power the strength of the structure and attachments of the seating are to be increased, special consideration being given to the power and type of engines and the relation of height of the engines to the width of the bedplate; particulars are to be submitted.

Boiler Bearers

2206 Boiler bearers are to be of substantial construction and efficiently supported by brackets. (*See* D 407 and D 507.)

Additional Strengthening in Machinery Space

2207 Additional transverse strengthening is to be provided by means of web frames and strong beams, with suitable pillaring or other arrangements.

Clearance between Bulkheads and Boiler

2208 Bunker and hold bulkheads are to be kept well clear of boilers and uptakes, and sufficient space is to be allowed all round boilers for proper access.

2209 Decks, or the tops of recesses, are to be not less than 4 feet clear of the top of the boiler. Uptakes and flat surfaces of boilers are to be not less than 18 inches, and the cylindrical shells of boilers not less than 9 inches, from coal bunker and hold bulkheads.

Protection of Decks under Donkey Boilers

2210 Decks under donkey boilers are to be increased ·10 inch in thickness and protected under coal-fired boilers by not less than 2 inches of firebrick or cement. These requirements are to extend to any part of the deck on to which fires from the donkey boiler may be drawn.

Exposed Casings Protecting Machinery Openings

2211 Engine and boiler openings on weather decks are to be protected by casings of adequate height having scantlings determined from Table 23 and associated notes. The tops of casings are to be suitably plated and stiffened.

2212 The deck openings should not be larger than necessary and suitable cross-tie arrangements are to be provided.

2213 On the uppermost continuous deck of ships in which the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and on raised quarter decks, the doors in exposed casings are to be of steel. All doors are to be strongly constructed and capable of being closed and secured from both sides.

The sills of exposed doorways on the uppermost continuous deck, where the draught is as defined above, are to be 24 inches in height above the upper surface of the deck; the sills of exposed doorways on raised quarter decks are to be 18 inches and those on other superstructure decks, including those extending for the full length of the ship, 15 inches in height.

Protected Casings

2214 The plating is to be not less than ·26 inch in cargo spaces and ·20 inch in accommodation spaces in superstructures; stiffeners are to be 3 × 2½ × ·26 inch angles spaced 30 inches apart. Where trunked casings form boundaries of coal bunkers they are to comply with the requirements of D 1805 to D 1808.

Skylights and Gratings

2215 Engine room skylights are to be substantially constructed and are to be securely connected to the coamings. Gratings over stokehold openings are to be protected by hinged plate covers, which are to be watertight if the level of the openings is less than 2 feet above the top of the hatch coamings required by D 2301. (*See also* F 202).

Aluminium Alloy

2216 When alluminium alloy is used in the construction of the boundaries of the machinery space or in the casings or pillars, suitable insulation is to be fitted so that the structure remains effective in the presence of intense heat. The extent of the insulation is to be governed by the fire risk on either side of the boundary.

Cross-references

2217 For scantlings of single bottoms in machinery space, *see* D 417.

For scantlings of double bottoms in machinery space, *see* D 533 and D 534.

For frames in boiler room, *see* D 614.

Section 23

HATCHWAYS AND DECK OPENINGS

Height of Coamings

2301 The minimum height of steel coamings above the upper surface of decks is to be as follows:—

On the weather portions of the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... ... 24 inches.

On the weather portions of superstructure decks, including superstructures extending for the full length of the ship, for the forward ·25L ... ... 24 inches, for the remainder and on raised quarter decks 18 inches.

On decks inside superstructures where the openings in the end bulkheads have no means of closing ... 18 inches.

On decks inside superstructures where the openings in the end bulkheads are closed by strong hinged wood doors, wood shifting boards fitted in channels or portable plates secured by hook bolts ... ... 9 inches.

2302 Hatchways on other decks and in positions not detailed in 2301 are to be suitably framed.

Construction of Coamings

2303 At hatchways exposed to the weather the thickness of the side and end coaming plates is to be ·44 inch where the length L is 200 feet or greater and ·36 inch where L does not exceed 100 feet with intermediate values obtained by interpolation. Coamings are to be stiffened on their upper edges by a substantial moulding. At hatchways below the uppermost continuous deck or within an intact superstructure the coamings are to be not less than ·40 inch in thickness.

2304 Angles connecting the coamings to the deck and the corner angles connecting the side and end coamings are to be of the same thickness as the coaming plates. Coaming angles are to extend ½ inch above the wood deck.

2305 Side coamings of all hatchways are to extend at least to the lower edge of the beams, which are to be attached to the coamings as required by Table 52 H.

For welded construction, *see* D 3106.

2306 Hatchway side and end coamings which are 24 inches or more in height are to be stiffened by a horizontal bulb angle, or equivalent, fitted near the upper edge of the coaming; in ships 250 feet or more in length the bulb angles are to be not less than 7 inches in depth. Additional support is to be afforded by fitting brackets or stays from the bulb angle to the deck at intervals of not more than 10 feet.

2307 The scantlings and arrangements of coamings more than 36 inches in height and of coamings acting as girders will be specially considered. (*See* D 1404 and D 1509 to D 1513.)

2308 Coamings are to be made watertight above the deck and coaming angles are to be suitably turned or the coamings welded.

Hatchway Beams and Carriers

2309 Scantlings of hatchway beams are to be determined from Table 43 and associated notes.

2310 Web plate beams are to be stiffened at their upper and lower edges by double angles or welded face plates, but when bulb plates are fitted this stiffening is required at the upper edge only. The upper angles or face plates are to extend to the extreme ends of the beams.

2311 The ends of the web plates are to be flushed up on each side by doubling plates of the same thickness as the mounting angles and at least 7 inches wide. In welded hatchways beams, equivalent arrangements for stiffening the ends of the web plates are to be adopted.

2312 At beams which carry the ends of wood hatch covers the web plate is to extend well above the top of the upper angles or face plate of the hatch beams. The bearing surface for hatch covers is to be not less than $2\frac{1}{2}$ inches. (*See* 2319.)

2313 Hatchway beams are to be supported at their ends by carriers, sockets or other suitable arrangements, having a minimum bearing surface of 3 inches. Carriers formed of angles are to be not less than ·50 inch thick and one angle is to be extended down to the level of the deck. If the carriers are of a form which will not permit of extension to the deck level the coaming plate is to be increased in thickness by $12\frac{1}{2}$ per cent, or equivalent strengthening provided.

2314 The bottoms of all carriers are to be of solid construction.

2315 Sliding hatchway beams are to be provided with an efficient device for locking them when in their correct fore and aft positions.

Hatch Covers

2316 Hatch covers are to be fitted to the hatchways of all decks, except that at hatchways on decks as defined in 2302 the hatch covers may be dispensed with if desired by the Owners and specially approved by the Committee when a suitable notation will be entered in the Register Book.

2317 The finished thickness of wood hatch covers at hatchways on weather decks, and in 'tween decks of normal height, is to be $2\frac{3}{8}$ inches for an unsupported span of 5 feet, and $3\frac{1}{4}$ inches for 6 feet 6 inches; the thicknesses for intermediate spans are to be in proportion.

When the 'tween deck height in cargo spaces exceeds 8 feet 6 inches the thickness of the covers is to be increased at the rate of 5 per cent per foot excess in 'tween deck height.

2318 The ends of all wood hatch covers are to be protected by encircling galvanised steel bands, about $2\frac{1}{2}$ inches wide and $\frac{1}{8}$ inch thick, efficiently secured.

2319 Hatch rests are to be of the same thickness as the mounting angles given in Table 43 A & B and are to provide at least $2\frac{1}{2}$ inches bearing surface for the hatch covers; they are to be bevelled if required to suit the slope of the hatches.

Tarpaulins and Securing Arrangements

2320 Tarpaulins in good condition are to be provided for all hatchways requiring coamings 9 inches or more in height; not less than two tarpaulins are to be provided for all hatchways in exposed positions.

2321 Tarpaulins are to be free from jute, thoroughly waterproofed and of ample strength. The minimum weight of the material before treatment is to be 19 ozs. per square yard if the material is to be tarred, 18 ozs. if to be chemically dressed or 16 ozs. if to be dressed with black oil.

A certificate to the above effect is to be supplied by the makers of the tarpaulins.

2322 Cleats are to be fitted at all hatchways requiring tarpaulins, spaced not more than 2 feet from centre to centre, the end cleats being arranged not more than 6 inches from the hatchway corners. Cleats are to be of an approved pattern at least $2\frac{1}{2}$ inches wide, with edges so rounded as to minimise the cutting of the wedges. The thickness should be not less than $\frac{3}{8}$ inch for angle cleats and $\frac{7}{16}$ inch for smithed cleats which should be stiffened by pressing out the centre to form a web extending to the bottom of the palm. Drop forgings should be of equivalent strength. Cleats should be so set as to fit the taper of the wedges.

2323 Battens and wedges are to be efficient and in good condition. Wedges are to be of tough wood, generally not less than 8 inches in length and 2 inches in width. They should be cut on a standard taper of one in six and should be not less than $\frac{1}{2}$ inch in thickness at the point.

2324 Where coamings are required to be 24 inches in height, steel bars or other equivalent means are to be provided for efficiently and independently securing each section of hatchway covers after the tarpaulins are battened down. Where hatchway covers extend over intermediate supports, steel bars or their equivalent are to be fitted at each end of each section of covers. At all other hatchways in exposed positions on weather decks, ring bolts or other fittings for lashings are to be provided.

Steel Hatch Covers

2325 When steel hatch covers are adopted, plans and particulars of the scantlings and arrangements are to be submitted.

Built steel covers are to be suitably framed to provide sufficient strength and rigidity, and the scantlings are to be determined from the formulæ given in Table 43, Note 6.

Securing cleats and cross joint wedges, together with suitable jointing material, are to be fitted to secure the tightness of the covers on hatchways for which the rule height of coamings required by 2301 is 9 inches or more.

The spacing of securing cleats is not to exceed 3 feet 3 inches where rule height of coamings is 24 inches, and 3 feet 6 inches where the rule height of coamings is 18 inches or 9 inches. The maximum spacing of cross joint wedges is not to exceed 4 feet. Suitable securing arrangements are to be fitted on other hatchways.

Steel pontoon hatch covers, that is steel covers having top and end plating with interior webs and frames, extending for the full width of the hatchway and about one quarter of the length, and not fitted with direct securing arrangements, are generally to be in accordance with the requirements of Table 43, Note 6. Where this type of cover is fitted at weather deck cargo hatchways within the forward ·25L the strength and inertia of the covers is to be at least 20 per cent above the formulæ given in Table 43 Note 6 Type A and the thickness of plating is to be at least 30 per cent above the thickness given by the same note.

Steel hatch covers with special sealing arrangements, or insulated covers, or steel hatch covers to which the requirements of 2320 to 2324 might wholly or in part be applied, will be specially considered.

Bunker, Access and Trimming Hatchways

2326 The construction and the closing and securing arrangements of bunker, access and trimming hatchways are to comply with the requirements of 2301 to 2325 so far as applicable.

Flush Bunker Scuttles

2327 Flush bunker scuttles may be fitted on superstructure decks, including raised quarter decks.

2328 The scuttles are to be substantially constructed with screw or bayonet joints. If the scuttles are not hinged the covers are to be permanently attached by a chain.

Trunked Hatchways

2329 When hatchways are trunked through one or more 'tween decks, and hatchway beams and covers are dispensed with at the intermediate decks, the hatchway beams, coamings and covers immediately below the trunk are to be adequately strengthened; plans are to be submitted for approval.

Companionways

2330 Companions on exposed decks are to be of steel effectively secured to the deck. The height of the doorway sill is to be as required for hatchway coamings in the same position.

2331 Within the forward ·25L the doors are to be of steel and elsewhere may be of hard wood not less than 2 inches in thickness. The doors are to be capable of being operated and secured from both sides.

Section 24

VENTILATORS, AIR PIPES AND SOUNDING PIPES

Ventilation, General

2401 Ventilators are to be sufficient in number and size to provide adequate ventilation for all spaces.

Where mechanical ventilation is adopted plans showing the construction of the weather deck fittings are to be submitted for approval.

Ventilator Coamings

2402 The minimum height of ventilator coamings above the upper surface of decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 36 inches.

On superstructure decks, including superstructures extending for the full length of the ship,
for the forward·25L ... ... 36 inches,
for the remainder and on raised quarter decks ... 30 inches.

Ventilator coamings of a greater height than 36 inches are to be specially supported and secured.

2403 The scantlings of the coamings and their attachment, if riveted to the deck plating, are to be in accordance with the following Table:—

Internal diameter of ventilator coamings		Coaming plate	Deck angle	Rivets at 4 dia. spacing centre to centre
Above	Not exceeding			
Inches		Inches	Inches	Dia.-Inches
—	8	·30	3 ×3 ×·34	$\frac{3}{4}$
8	11	·32	3 ×3 ×·36	$\frac{3}{4}$
11	13	·34	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot38$	$\frac{3}{4}$
13	15	·36	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot40$	$\frac{3}{4}$
15	17	·38	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot42$	$\frac{7}{8}$
17		·40	$3\frac{1}{2}\times3\frac{1}{2}\times\cdot44$	$\frac{7}{8}$

2404 When the deck is sheathed with wood the vertical flange of the coaming angles is to extend $\frac{1}{2}$ inch above the wood sheathing.

2405 The deck plating in way of ventilator coamings is to be efficiently stiffened between the beams or longitudinals.

Covers

2406 All ventilator coamings are to be provided with strong plugs and canvas covers, or equally efficient appliances, for closing the openings when the cowls are unshipped.

Minor Ventilators

2407 Mushroom and gooseneck ventilators are to be strongly constructed and efficiently secured to the deck plating.

Air and Sounding Pipes

2408 Air and sounding pipes are to be fitted in accordance with the requirements of Chapter E.

2409 The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck ... 36 inches.

On raised quarter decks ... ... 30 inches.

On superstructure decks other than raised quarter decks but including those extending for the full length of the ship ... ... 18 inches.

2410 Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

2411 Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

2412 In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Section 25

BULWARKS, FREEING PORTS, SCUPPERS, SANITARY DISCHARGES AND SIDE SCUTTLES

Bulwarks

2501 Plate bulwarks are to be stiffened by a strong rail section and supported by stays from the deck, spaced not more than 6 feet apart. Where bulwarks are cut to form a gangway or other opening, stays of increased strength are to be fitted at the ends of the openings. The plating in way of mooring pipes is to be doubled or increased in thickness.

2502 The arrangements for continuity of strength at the ends of superstructures are to be as required by D 1206. Bulwarks should not be cut for gangway or other openings near the breaks of superstructures.

2503 In welded ships, the bulwarks should be arranged to ensure their freedom from main structural stresses. (*See* D 3107.)

2504 The bulwarks of ships carrying timber deck cargoes are to be not less than 39 inches in height and are to be additionally stiffened at the upper edge; bulwark stays are to be attached to the deck in way of beams.

Freeing Ports

2505 Where weather decks are enclosed by bulwarks ample provision is to be made for rapidly freeing the decks from large quantities of water by means of freeing ports.

2506 The area of freeing port openings at uppermost continuous decks where the draught is the maximum permitted for the dimensions of the ship with the depth D measured to that deck, and at raised quarter decks, is to be as follows:—

Length of well	Area on each side	Length of well	Area on each side
Feet	Square feet	Feet	Square feet
15	8	55	12
25	9	65	13
35	10	75	15
45	11	85	17

On superstructures, other than raised quarter decks, but including those extending for the full length of the ship, the area of the openings is to be half the area given in the preceding Table.

In ships having deficient sheer or where there is no free passage for water across the weather deck, the freeing port area is to be suitably increased or open rails are to be fitted.

Provision is also to be made for freeing water from all open or partially open spaces in which water may be shipped and contained.

2507 The lower edges of freeing ports are to be as near to the deck as practicable and the openings are to be protected by rails spaced not more than 9 inches apart.

If hinged doors are fitted over the openings their hinges are to have brass pins; fittings for keeping the doors closed are not to be provided.

Scuppers

2508 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

2509 When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

2510 Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

2511 Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screw-down non-return valves as required by 2510.

2512 Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

2513 Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

2514 Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

2515 Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges

2516 Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

2517 Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

Materials for Valves and Pipes

2518 Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

Protection of Pipes and Valves

2519 In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

Side Scuttles

2520 Side scuttles and deadlights are to be of approved design and are to be made of approved material other than ordinary cast iron.

Side scuttles to spaces below the freeboard deck or to spaces within enclosed superstructures are to be fitted with efficient inside deadlights permanently attached and capable of being closed watertight.

In enclosed superstructures permanently allocated to passengers or crew portable deadlights may be provided if stowed adjacent to the scuttles, provided they are accessible at all times in service.

Section 26

RUDDERS

Materials

2601 Steel castings are to comply with the requirements of P 5.

2602 Forgings made of ingot steel are to comply with the requirements of P 6.

2603 If forgings are made from scrap material, either iron or steel scrap may be used, but a mixture of iron and steel is not permitted.

Diameter of Rudder Head and Mainpiece

2604 The diameter of the rudder head is to be determined from Table 44 and associated notes.

2605 The mainpiece of rudders with cast or forged frames is to be of the same diameter at the top pintle as the rudder head and is to taper evenly to the heel, where the diameter is not to be less than 75 per cent of that of the head.

2606 If the supports of the rudder are so arranged that considerable bending stresses may occur in the mainpiece and head these are to be suitably strengthened.

Single Plate Rudders

2607 The thickness of plates and scantlings of arms of single plate rudders are to be determined from Table 45 and associated notes.

2608 Arms are to be arranged on alternate sides of the plate and are to be shrunk on to the mainpiece and keyed. In way of each arm the mainpiece is to be increased in diameter by 10 per cent; this increased diameter is to extend above and below the arm for a distance equal to the increase in diameter and beyond these points is to be gradually reduced to the normal diameter of the mainpiece over a distance of one-fifth of the diameter.

2609 The thickness of the key is to be 10 per cent of the normal diameter of the mainpiece at each arm, and the width is to be twice the thickness.

Double Plate Rudders

2610 The scantlings of cast or forged frames of double plate rudders will be determined in relation to their design. The thickness of the plates is to be derived from Table 46 and associated notes.

2611 The scantlings of rudders with plate frames will depend upon the arrangements adopted. The thicknesses of the outside plates and of the horizontal and vertical web plates are to be determined from Table 46 and associated notes. Special attention is to be given to the attachment of the pintles and rudder coupling to the body of the rudder.

2612 Horizontal and vertical webs are not to be attached to side plates by tongue welds. Slot welds are only to be used in association with flat bars on the edges of the webs.

2613 The internal surfaces of double plate rudders are to be efficiently coated and means for draining the rudder are to be provided.

Pintles

2614 The scantlings of the pintles are to be determined from Table 47 and associated notes.

2615 The distance between the top pintle and the bearing of the rudder stock should be as short as possible; where the ratio of the unsupported length to the diameter of stock is excessive the diameter of the stock may require to be increased or the length reduced by fitting an additional and accessible bearing.

2616 Where liners to pintles are fitted they are to be shrunk on to the pintles or otherwise efficiently secured.

Couplings

2617 The scantlings of couplings are to be determined from Table 48 and associated notes.

2618 The bolts are to be fitted and suitable arrangements are to be made to lock the nuts.

Riveting

2619 The diameters of rivets in rudder arms are given in Tables 45 and 46.

The rivets are to be spaced $4\frac{1}{2}$ diameters apart and the holes are to be countersunk. Where the breadth of the arm exceeds $4\frac{1}{2}$ inches the riveting is to be reeled and if the breadth exceeds 7 inches two complete rows of rivets are to be fitted, but, except at the outer ends of the arms, the rivets are not to be directly opposite to each other.

General

2620 Suitable arrangements are to be provided to prevent the rudder from lifting.

2621 When the weight of the rudder is supported by a carrier bearing attached to the rudder head the structure in way is to be adequately strengthened for that purpose. The plating under all rudder head bearings or rudder carriers is to be increased in thickness or doubled.

2622 In ships with a high astern speed the scantlings of rudder are to be specially considered.

Cross-reference

2623 For strengthening for navigation in ice, *see* D 1006, D 1014 and D 1022.

Section 27

STEERING GEAR

2701 All ships are to be provided with two independent means of steering. In ships exceeding 200 feet in length one of the gears is to be operated by power sufficient to put the rudder from hardover to hardover in 30 seconds while the ship is going ahead at full sea speed. All gears are to be fitted and tested under working conditions to the satisfaction of the Surveyors.

2702 Particulars of the proposed alternative means of steering are to be submitted for approval. Hand gear of the right and left handed screw and nut type is not to be fitted in ships exceeding 300 feet in length.

2703 No additional means of steering will be required where electric or electric-hydraulic steering gear is fitted having two independent motors or sets of pumps and motors with separate leads from the source of power. With steam-hydraulic steering gears similar arrangements will be accepted.

2704 After hand steering wheel and gear in ocean-going ships are to be adequately protected.

2705 The steering gear is to be secured to the seating by fitted bolts and suitable buttressing arrangements are to be provided.

Tillers and Quadrants

2706 The scantlings of tillers and quadrants are to be as given in Tables 49 and 50. Tillers and quadrants are to be shrunk on or bolted to the rudder head, in addition to being secured by a key of suitable dimensions. The keyways are to have rounded ends. The thickness of quadrant plates is to be 1 per cent of the radius given in the Table. The area of the arms at ends may be one-third of the area given in Table 49. Arms of loose quadrants not keyed to the rudder head may be of these reduced dimensions throughout their length, and the depth of the boss may be reduced by 10 per cent.

Rod and Chain Gears

2707 Steering rods and chains are to have the diameters required by Table 49 for the radius of quadrant given therein. Shackles, shackle pins, links and other connections are to be suitable for the size of chain.

2708 All steering chains are to be subjected to the breaking and proof tests for short link chains given in P 13. These tests are to be carried out at a proving establishment recognised by the Committee and the certificates are to be produced.

2709 The leads of the steering chains are to be as direct as possible and sharp bends are to be avoided. The diameters of leading block sheaves, measured at the centre of the chain, are to be not less than sixteen times the diameter of the steering chains; the pins of the sheaves are to have not less than twice the diameter of the chains.

2710 A set of spares is to be provided consisting of one complete spring buffer and one extra spring, two tested chains each equal to the longest length in the gear, two Warwick screws, four shackles, four connecting links and four rod pins.

In ocean-going ships, the speed of which is 12 knots and above, one buffer spring, one Warwick screw and one length of chain may be dispensed with.

In ships engaged on short sea routes which have either a main gear which is hand operated at sea or an auxiliary gear, independent of the rods and chains, which can be effectively operated at sea, the spare gear may be confined to sufficient shackles or split links to enable repair of the gear to be readily effected in the event of its breakdown at sea. In all other ships engaged on short sea routes, the spare gear is to be as required for ships the speed of which is 12 knots and above.

Springs

2711 Springs, buffers or equivalent arrangements are to be fitted to all main steering gears.

Locking or Brake Gear

2712 An efficient locking or brake arrangement is to be fitted to all gears to keep the rudder steady when necessary.

In bow rudders where a vertical locking pin is operated from the deck above, positive means are to be provided to ensure that the pin can be lowered only when the rudder is exactly central. In addition, an indicator is to be fitted at the deck to show when the rudder is exactly central.

Rudder Stops

2713 Stops for the rudder are to be provided and strongly secured to the deck in way of the tiller or quadrant tiller. Stops on the steering engine are to be arranged at a smaller angle of helm than those for the rudder.

Section 28

MASTS AND RIGGING

Masts and Derrick Posts

2801 The scantlings of stayed and unstayed masts and derrick posts equipped with derricks of normal outreach intended for a working load not exceeding 8 tons each are to be determined from Table 51 and associated notes. For stayed masts the Table does not provide for more than one derrick plumbing any one hatch or for two derricks working outboard; the load for use in the Table is the working load of the heaviest derrick on the mast. For unstayed masts or derrick posts, the Table provides for two derricks working simultaneously in one direction and the load to be used in the Table is the sum of the working loads of the two derricks.

2802 The scantlings and arrangements will be specially considered if desired when :

the working load of any derrick exceeds 8 tons; or

the length of a derrick exceeds the length of the mast or derrick post by more than 20 per cent; or

the derrick heel fitting is more than 8 feet above the deck; or

for stayed masts, the arrangement of standing rigging differs from that given in 2804.

2803 Masts and derrick posts are to be increased in thickness, or doubled, at the heel, deck and hounds and in way of the derrick fittings ; they are to be efficiently supported below the heel.

Standing Rigging

2804 Two shrouds, of standing rigging quality as defined in P 1405, are to be fitted on each side of stayed masts. The shrouds are to be attached at the sides of the ship at distances forward and aft of the mast each equal to one quarter of the beam of the ship or one quarter of the length of the mast, whichever is the greater. The circumference of each shroud is to be $2\frac{1}{2}$ inches where there are no derricks, 4 inches where four-ton derricks are fitted, and 5 inches where eight-ton derricks are fitted. Alternative arrangements of standing rigging will be considered in conjunction with the scantlings of the masts. Topmasts are to be efficiently stayed.

2805 Particular attention is to be paid to the strength and workmanship of all parts of the rigging and its connections. Smithwork is to be of best quality wrought iron or mild steel. The hull structure is to be effectively strengthened in way of chain plates or similar fittings. Standing rigging is to be properly set up.

Masts with Outriggers

2806 Where outriggers at mast heads are of unusual spread the scantlings of masts and rigging will be specially considered.

Cross-references

2807 For riveting, *see* Table 52 H.

For lightning conductors, *see* M 1801 to M 1806.

Section 29

CEILING AND CARGO BATTENS

Ceiling

2901 In single bottom ships close ceiling is to be laid on the floors to the upper part of the bilges. Limber boards are to be arranged to provide easy access to the bilges.

2902 In ships having double bottoms ceiling is to be laid over the bilges and under hatchways; the ceiling over the bilges is to be arranged with hatches which are readily removable. Ceiling under hatchways may be omitted provided the thickness of the inner bottom plating in way is increased by ·08 inch.

2903 The spaces between the frames at the top of the bilge ceiling are to be closed by wood chocks and cement or other suitable means.

2904 Ceiling is to be laid either directly on the inner bottom plating embedded in a substantial composition such as Stockholm tar and cement, or on battens providing a clear space of at least $\frac{1}{2}$ inch for drainage. (*See* 2907.)

2905 The thickness of wood ceiling is to be not less than 2½ inches in ships exceeding 200 feet in length nor than 2 inches in smaller ships.

2906 Where the covers or fittings of the manholes of the inner bottom in cargo holds project above the plating they are to be protected by a steel coaming around each manhole, fitted with a hatch of wood or steel.

Cross-references

2907 The requirements for ceiling over double bottom tanks where oil fuel is carried are given in D 2026.

2908 For ceiling in ships which are to be regularly discharged by grabs, *see* D 525.

For arrangements in way of refrigerated holds, *see* N 415 to N 416.

Cargo Battens

2909 Cargo battens are to be fitted in the holds from above the upper part of the bilge to the under side of beam knees, and in all cargo spaces in 'tween decks and superstructures up to the under side of beam knees.

2910 Wood cargo battens are to be 2 inches in thickness in ships exceeding 200 feet in length and 1½ inches in smaller ships; the clear space between the adjacent rows is not to exceed 9 inches.

2911 Battens may be dispensed with at the request of the Owners; the notation "NS" will appear in the Register Book.

Section 30

PROTECTION OF STEELWORK

Cementing

3001 In single bottom ships the shell plating and framing to the upper part of the bilges are to be effectively covered by an approved type of cement, asphalt or other coating. Free edges of the coating are to be of proper thickness, clear watercourses are to be maintained throughout.

3002 In double bottom tanks under the boiler room the frames and shell plating are to be effectively covered by an approved type of cement or other coating unless the tanks are used solely for oil fuel; elsewhere in the double bottom the cement or coating may be dispensed with. The bilges are to be cemented or effectively coated.

Painting

3003 All steelwork not protected as required by 3001 and 3002 is to receive at least two coats of paint of suitable composition except inside tanks intended for oil; tanks not intended for oil may be coated with cement wash.

General

3004 Millscale should be removed from external shell plating, and it is recommended that shot blasting, pickling or other equally effective means be employed for this purpose. If flame-cleaning is adopted, it is to be followed by wire brushing or grinding. Where reliance is placed on weathering and wire-brushing, the coating of the external surface should be delayed as long as possible to facilitate the removal of the millscale.

3005 Experience has shown that when several months elapse between the dates of launching and commissioning it is highly desirable to dry-dock ships immediately before going into service, in order to clean, examine and recoat the bottom. Experience has also shown the desirability of dry-docking for the same purpose when a ship has been about six months in service.

Section 31

WELDED CONSTRUCTION

General

3101 Where electric arc welding is to be used for the main structure the arrangement of the plating, disposition and type of joints, together with the proposed sequence of prefabrication, assembly and welding, are to be submitted for approval. The extent to which automatic welding is to be used should be indicated.

Details of welded connections of main structural members with type and size of welds are to be clearly indicated on the plans submitted for approval.

The approved arrangements, sequences and procedures are not to be departed from without approval.

3102 The structural arrangements are to be such as will admit of easy access for welding operations and will facilitate the use of downhand welding wherever possible.

The type and disposition of connections and sequences of welding are to be so planned that any restraint during welding operations is reduced to a minimum.

3103 The electrodes used are to be approved by the Committee and are to be suitable for the type of joint. The requirements for electrodes are given in P 15.

Quality of Material

3104 For ships of 300 feet in length and over, in which the seams and butts of the shell plating and strength deck are welded, steel of Grade D (see P 2, Table II) will generally be required for the following parts of the main structure when the thickness exceeds ·80 inch:—

Sheerstrake, stringer plating and deck plating of strength deck within ·4L amidships and plating at breaks of superstructure and corners of openings outside ·4L amidships.

Bottom shell to upper turn of bilge within ·4L amidships. When the bottom shell is of Grade D steel, the keel is also to be of that grade.

When necessary the application of the above requirements to ships less than 300 feet long will be specially considered.

3105 In ships over 350 feet in length, a riveted stringer angle, or alternatively a gunwale construction incorporating steel of specially high notch toughness (Grade E), may be required.

Structural Details

3106 Special attention is to be paid to structural continuity. Abrupt changes of shape or section and all sharp corners are to be avoided. The plating at corners of all openings in strength decks and shell plating is to be well rounded.

Where the deck is connected to the main hatchway coamings by welding, the deck opening and the coamings at the corners of the hatchways are to be rounded with a radius of not less than $\frac{1}{24}$ of the breadth of the opening; the minimum radius is to be 6 inches.

If the deck plating extends inside the coamings the coamings may be square at the corners, provided the side coamings are extended in the form of a tapered bracket and the deck plating at the corners is rounded as required by the preceding paragraph; the minimum radius in this case is to be 12 inches.

Where the deck is connected to the coamings by welding, the strength deck plating at the corners of all large openings is to be increased in thickness; welded doubling plates are not to be fitted. The seams and butts of the deck plating are to be kept well clear of hatch corners.

Where the deck plating stops at the coaming and is welded thereto, through penetration welds are to be used. Where the deck plating extends inside the coaming, the free edges of the plating in way of the hatchways are to be reasonably smooth and free of weld attachments.

Arrangements at the welded corners of machinery casings will be specially considered.

3107 Bulwarks, fairlead stools, mouldings, or other fittings are not to be welded to the top of the sheerstrake within ·5L amidships. The top edge of the sheerstrake is to be free of all notches and is to be reasonably smooth.

The endings of bulwarks, bilge keels or similar attachments to the hull are to be gradually tapered.

3108 Where stiffening members cross butts or seams of plating the webs of the stiffening members should be scalloped. The webs of stiffening members and bilge keels should also be scalloped at their butts.

Local concentration of welds should be avoided.

Where thick plates are butt welded to thin plates the edge of the thick plate may require to be chamfered.

3109 Individual connections part welded and part riveted are to be avoided and shall not be adopted unless specially approved.

3110 The thickness of plating may in certain cases require to be increased to take account of the greater area of panels resulting from the omission of faying flanges of the supporting structure.

Welded Joints and Connections

3111 Butt Welds Butt welds should be adopted in preference to overlaps for joints in the main structure. In general, the edges of plates to be joined by manual welding are to be bevelled on one side or on both sides of the plates to provide an included angle of from 50 to 60 degrees.

Where it is desired to adopt other forms of edge preparation full details are to be submitted for approval.

A back sealing run is to be applied to all single V butt welds and to square edge butts where main welding is carried out from one side only.

3112 Fillet Welds The dimensions of fillet welds for various structural connections are to be as required by Table 52.

3113 Tee Connections The leg length of the fillets is to be governed by the thickness of the abutting plate or web. Where the difference between the thicknesses of the parts to be joined is considerable, the size of the fillet will be specially considered.

Tee connections should be made by fillets on both sides of the abutting plate. Where the abutting plate is bevelled a sealing run should be applied on the reverse side.

3114 INTERMITTENT FILLETS. The length of intermittent welds is to be measured over the correctly proportioned fillet, clear of end craters.

Intermittent fillets are to be doubled at, and carried round the end of brackets of, hold frames, longitudinals, beams, bulkhead and floor stiffeners, and of floors to shell, inner bottom and centre girder.

3115 SCALLOPS AND NOTCHES. The details of scalloped construction are given in Table 52 G. All scallops are to have well rounded corners and smooth edges. Scallops are not to be cut in way of the toes of bracket connections or at other parts where stress concentrations may develop.

Scallops in side frames, longitudinals and stiffeners are to be omitted for at least 9 inches on each side of the intersection with a primary supporting member.

Notches in primary supporting members are not to be larger than necessary, and are to have well rounded corners and smooth edges. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted.

Additional Attachment

3116 Welded connections may be required to be increased to meet particular local stresses, or where otherwise necessary.

Overlap Joints

3117 Where overlapped joints of plating are adopted, the breadth of the overlap is to be four times the thickness of the thinner of the plates so joined, but need not exceed 2 inches.

Workmanship

3118 Welding operators are to be proficient in the type of work on which they are engaged. A sufficient number of skilled supervisors is to be provided to ensure effective control at all stages of assembly and welding operations. The welding plant and appliances are to be suitable for the purpose intended and are to be maintained in an efficient condition.

3119 Procedures for the welding of all joints are to be established for the types of electrode, edge preparation and welding position proposed. For this purpose, the surveyors may require sample tests to be prepared under similar conditions to those which will obtain during construction.

The diameter of electrode, current, voltage, rate of deposit and number of runs are to conform, as far as practicable, to those established in accordance with the preceding paragraph. Provision is to be made for checking the current in the vicinity of the arc.

3120 The preparation of plate edges is to be accurate and uniform. All joints are to be properly aligned and closed or adjusted before welding. Excessive force is not to be used in fairing and closing the work. Means are to be provided for holding the work in proper alignment without rigid restraint during welding operations.

Where excessive gaps exist between surfaces or edges to be joined, the corrective measures adopted are to be to the satisfaction of the Surveyors.

3121 Tack welding should be kept to a minimum and where used the tack weld should be equal in quality to the finished welds. All defective tack welds should be cut out before completing the finished welds.

Care should be taken when removing tack welds and temporary fittings used for assembly to ensure that the material of the hull is not damaged.

3122 The surfaces of all parts to be welded are to be clean, dry and free from rust, scale and grease. The surfaces and boundaries of each run of deposit are be to thoroughly cleaned and free from slag before the next run is applied.

Before a sealing run is applied to the back of a weld, the original root run is to be cut back to sound metal.

Welding is to proceed systematically, each welded joint being completed in proper sequence without undue interruption.

Adequate protection is to be provided where welding is required to be carried out in exposed positions in wet, windy or cold weather. In cold weather precautions should be taken to screen and pre-warm the work to prevent too rapid cooling of the weld; special care is necessary when welding thick material.

3123 All finished welds are to be sound, uniform and substantially free from slag inclusions, porosity, undercutting or other defects. Care is to be taken to ensure thorough penetration and fusion.

3124 Where the structure embodies both welding and riveting, welded joints are in general to be completed before riveting in their vicinity.

Inspection

3125 Effective arrangements are to be provided for the inspection of finished welds, in order to ensure that all welding has been satisfactorily completed.

Visual inspection may require to be supplemented by other forms of non-destructive crack or flaw detection methods for the examination of important structural welds. A system of radiographic examination should be used wherever practicable, and where this is available the Surveyors are to collaborate with the builders in this system of inspection.

All defective sections of welds are to be cut out and carefully rewelded.

3126 Alternative proposals for methods of welding considered by the Committee to be equivalent to those set forth in the Rules will be accepted.

Welding of Aluminium Alloys

3127 Where welding of aluminium alloys is employed, the requirements as laid down in this section are to be carried out in so far as they are applicable, with the following additions:—

The edges of the material to be welded are to be clean and freed from grease by chemical or solvent cleaning. The joint edges should be scratch brushed—preferably immediately before welding—in order to remove oxide or adhering films of dirt, filings, etc.

Parts to be welded should be set up in such a way that contraction stresses are kept to a minimum.

For welding processes and filler wire, *see* P 18.

Section 32

RIVETED CONSTRUCTION

Riveted Connections

3201 The requirements for riveted connections and the diameter and spacing of rivets in the various parts of the structure are given in Table 52. The diameter of the rivets is to be regulated, in general, by the greater thickness of the parts to be connected, but where the difference is considerable special consideration will be given. (*See also* Notes to Table 52.) Where frame spacing wider than that given in the Tables is adopted the diameter and the number of rows of rivets are to be regulated by the thickness of the plating required at the Table frame spacing.

3202 The breadths of the flanges of connecting angles or other sections are to be generally not less than four times the diameter of the rivet for rivets up to $\frac{7}{8}$ inch in diameter and three and one-half times for rivets of 1 inch diameter or over.

3203 Chain riveting is to be adopted for the butts and seams of plating. In the connections to bar keels, stems and sternframes and in double riveted stringer angles, boundary angles and frame connections the rivets are to be reeled.

Form of Rivets

3204 Rivets are to be suitably formed to fill the rivet holes completely. Where the holes have been punched the rivets are to be increased under their heads. The heads of pan headed rivets are to have a depth of ·7 and a diameter at the bottom of the head of 1·6 times the diameter of the rivet. Where countersunk headed rivets are used the heads are to be suitable for the countersinking of the material.

Countersinking

3205 Rivet holes are to be countersunk on the caulking side of plating, and in boundary connections, of shell, weather decks, inner bottom, double bottom tank ends, crowns and bulkheads of peak tanks, deep tanks and oil fuel bunkers. The holes in the margin plate to take gusset plate rivets are also to be countersunk.

3206 The countersinking of the holes is to extend through at least nine-tenths of the thickness of the plates or angles where the thickness does not exceed ·50 inch and through at least eight-tenths where the thickness is above ·50 inch.

3207 The angle of countersink for material not exceeding ·50 inch in thickness is to be about 60 degrees; for plating exceeding this thickness the angle is to be about 45 degrees.

Workmanship

3208 Workmanship is to be well executed and submitted to close inspection throughout the preparation and building of the ship. The various parts of the structure are to be faired and properly closed.

3209 Punches, dies and shears are to be maintained in good condition and the clearance between the punch and the die is to be kept as small as possible.

Plating

3210 The preparation of plate edges is to be accurate and uniform. Shearing is to be carried out from the faying surface wherever practicable. Any burr on plates or sections preventing the closing of work is to be removed.

3211 All caulking edges are to be planed, flame cut, chipped fair, or otherwise suitably prepared.

Liners and Joggling

3212 Where plates or sections are joggled care is to be taken that the joggle is of the correct depth and rivet holes are to be clear of the joggle.

3213 Liners, if fitted, are to be in one piece of the proper thickness and of breadth not less than the flange of the faying section. Holes in liners are to be of the same diameter as those in the plate and section.

Riveting

3214 Rivet holes may be drilled or punched and are to be countersunk where required by 3205 to 3207. Punching is to be carried out from the faying surface wherever practicable.

3215 Any burr caused by drilling or punching is to be removed before the work is closed for riveting.

3216 Unfair rivet holes are to be remedied by reamering and rivets of an appropriate diameter are to be used. Where necessary the holes are to be recountersunk and the faying surfaces cleaned.

3217 Rivet holes in the frames at the turn of the bilges and at bossing are not to be drilled or punched to their full diameter before the frames have been shaped.

3218 Service bolts of requisite size and number are to be used to hold the parts in position and in close contact.

3219 The heads of the rivets are to be properly laid up and the work performed so that the holes are completely filled. Points of rivets are to be kept full but are not to be spread over the plating. In holes which are not countersunk the rivets are to be finished with specially full or snap points.

3220 Rivets in all parts are to be spaced to ensure the efficient closing of work. Particular care is to be taken with three-ply riveting.

Caulking

3221 Caulking is to be thoroughly executed. Stop waters of suitable material may be fitted where necessary; otherwise the use of soft packing is to be kept to a minimum. Thick packing is not to be used.

Oil-tight Riveted Work

3222 The requirements of 3201 to 3221 are to be complied with.

3223 Faying surfaces are, in general, to be fitted steel to steel; but where packing is necessary the material used is to be as thin as possible and not soluble in oil.

3224 Where there may be difficulty in securing fairness rivet holes are to be drilled in position or punched small and reamered.

3225 Where boundary angles are double both flanges of each bar are to be caulked and countersunk headed rivets are to be used.

3226 Where fitted on caulking surfaces angle or T-bar connections are to be caulked.

3227 Attachments of fittings are to be made as far as possible without piercing the plating; where through fastenings are necessary they are to be tapped and efficiently secured to the plating.

Section 33

EQUIPMENT

General

3301 The regulations governing the assignment of the figure 1 for equipment are contained in B 201 and B 202.

3302 To entitle a ship to the figure 1 the equipment is to be in accordance with the following requirements and Table 53. For ships engaged on a special or restricted service an equipment less than the Table requirements may be approved by the Committee if considered suitable for the particular service on which the ship is to be engaged.

Equipment Number

3303 The equipment of anchors, chain cables, wires and ropes given in Table 53 and associated notes is based on an "Equipment Number" which is to be the sum of the numbers calculated as follows:—

For the Hull:—

$$\text{Number} = L\,(B+d) + \cdot 85\,L\,(D-d)$$

(For definitions of L, B, D and d *see* D 201 to D 204; D is to be measured to the uppermost continuous deck.)

For Superstructures, i.e., for those parts of the structure which extend athwartships to the side of the ship or are set inboard not more than 12 inches; also for continuous trunkways:—

$$\text{Number} = \cdot 85\,(l \times h)$$

where l=overall length of superstructure, including rounded ends, in feet,

h=height from deck to deck, in feet.

Projections beyond the length l, i.e., structure not extending to, or within 12 inches of, the side of the ship may be treated as Other Erections. (*See* below.)

Where promenade spaces are enclosed by screens at the side of the ship, the length so enclosed is to be treated as superstructure.

For Other Erections:—

$$\text{Number} = \cdot 75\ (h \times l)$$

where h=height, in feet,
l=overall length, in feet.

The following need not be included in computing the number:—

All parts outside the length L.

Isolated erections when both length and breadth are less than one-half B.

Hatch coamings unless forming part of a continuous trunkway.

Anchors

3304 Anchors are to be of approved design. The radii on all parts of the anchor head are to be as large as possible, particularly where there is a considerable change of section. The heads of stockless anchors, including pins and fittings, are not to be less than 60 per cent of the total weight of the anchor. Where anchors with stocks are provided the weight of the stock is to be 25 per cent of the total weight of the anchor including shackle, etc., but excluding stock.

Chain Cables

3305 Chain cables may be of wrought iron, mild steel or special quality steel in accordance with the requirements of P 13. The form and proportions of the links and lugless or D shackles are to be in accordance with recognised practice.

Testing of Equipment

3306 All anchors and chain cables are to be tested at establishments and on machines recognised by the Committee or controlled by a Government, municipal or similar responsible body, and in accordance with the requirements of P 11, P 12 and P 13.

Test certificates showing particulars of weights of anchors, or size and weight of cable and of the test loads applied are to be furnished. These certificates are to be examined by the Surveyors when the anchors and cables are placed on board the ship.

3307 The notation "LACP" will be entered in the Appendix to the Register Book when the anchors and chain cables have been tested at licensed proving establishments in Great Britain or have been tested under the supervision of the Society's Surveyors at other proving establishments on machines recognised by the Committee.

3308 When the anchors and chain cables have been tested on a machine controlled by a Government, municipal, or similar responsible body in accordance with the Rule requirements, although not under the supervision of the Society's Surveyors, and test certificates signed by a competent authority are produced for the Surveyor's examination and verified, the equipment will be accepted, but the notation "LACP" will not be made in the Appendix to the Register Book.

3309 Steel wire ropes are to be tested as required by P 14.

Arrangements for Working and Stowing Anchors and Cables

3310 A windlass of sufficient power and suitable for the size of chain cable is to be fitted and efficiently bedded and secured to the deck. The thickness of the deck in way of the windlass is to be increased and adequate stiffening is to be provided, to the Surveyor's satisfaction.

3311 An easy lead of the cables from the windlass to the anchors and chain locker is to be arranged.

3312 Hawse pipes are to be of ample thickness and of a suitable size and form to house the anchors efficiently. Substantial chafing lips are to be provided at the shell and deck. The shell plating and framing in way of the hawse pipes are to be reinforced as necessary.

3313 The chain locker is to be of a capacity and depth adequate to provide an easy direct lead for the cable into the chain pipes, when the cable is fully stowed. Chain or spurling pipes are to be of suitable size and provided with chafing lips. The port and starboard cables are to be separated by a division in the locker, and provision is to be made for securing the inboard ends of the cables to the structure.

3314 Satisfactory arrangements are to be made for the stowage and working of the stream anchor if provided.

Cross-reference

3315 For the equipment of tugs, *see* D 3511.

Section 34

RECOMMENDATIONS IF ADDITIONAL STRENGTHENING FOR HEAVY CARGOES IS DESIRED

General

3401 The following recommendations are inserted for the guidance of Owners who desire to provide additional strengthening to ships regularly engaged in onerous heavy cargo trades.

3402 The scantlings, arrangements and equipment should be as required by Sections D 1 to D 33, modified as follows.

Structural Design

3403 The double bottom and strength deck should be longitudinally framed.

Double Bottom Structure

3404 PLATE FLOORS Under cargo holds abaft ·25L from forward plate floors should be fitted on alternate frames in way of the hatchways, but may be on every third frame, with maximum spacing of 8 feet, clear of hatchways.

3405 INNER BOTTOM LONGITUDINALS The section modulus of the inner bottom longitudinals shall be derived from Table 10 and associated notes increased by 20 per cent in way of the hatchways and 10 per cent clear of the hatchways.

Struts should not be fitted to the longitudinals between the floors.

3406 CENTRE GIRDER When the maximum spacing of the plate floors is 8 feet, the height of the centre girder should be increased 20 per cent above that required by Table 6; when the maximum spacing of floors is 6 feet or less, the height of the centre girder may be as required by Table 6.

3407 SIDE GIRDERS Side girders should not be less than required by D 503.

An additional side girder should be fitted abaft the engine room, extending for the full length of the hold.

3408 INNER BOTTOM PLATING The thickness of the inner bottom plating should be increased by ·20 inch above the requirements of Table 6 or alternatively double ceiling should be fitted.

Side Framing

3409 In the holds the height of the tank side brackets above the tank top as required by Tables 6 and 11 should be maintained. The arms of the lower deck beam knees should be increased by 6 inches and the riveting correspondingly increased. The frames and beams should not be reduced in size on account of this increase.

Decks

3410 The sectional area of the strength deck plating as derived from Table 18 and associated notes should be increased by 10 per cent for ·4L amidships.

3411 STRONG HATCH SIDE COAMINGS AND END BEAMS UNDER CARGO DECKS The scantlings should be determined by the numeral derived from the notes to Table 29 increased by 10 per cent.

Section 35

TUGS

General

3501 The scantlings and arrangements of tugs are to be as required by the preceding Sections of this Chapter except where otherwise specified in this Section.

The draught d, used for determination of scantlings, is not to be less than ·85 D.

Class

3502 Tugs built in accordance with the requirements of this Section will be classed 100A1 Tug.

3503 Where tugs are intended for service in sheltered waters only, the class will be A1 Tug with a class notation indicating the limits of the service. Suitable modifications in the scantlings, arrangements and equipment may be approved by the Committee.

Floors

3504 Floors in tugs having single bottoms may be flanged $3\frac{1}{2}$ inches on the upper edge instead of having reversed frames, except in the engine room and under the boiler bearers where double reversed frames are to be fitted as required by D 407.

Keelsons

3505 The scantlings of keelsons are to be in accordance with the requirements for tugs given in Table 5.

Bulkheads

3506 Watertight bulkheads are to be constructed generally as required by D 16, but the stiffeners may be determined from Table 35.

Machinery Casings

3507 Machinery casings are to be not less in height than 3 feet above the upper surface of the deck.

Casings extending to the bottom of the beams are to be connected to the beams; the deck connection may be made by a single riveted angle or equivalent. If the casings do not extend to the bottom of the beams the casing connection to the deck is to be double riveted or equivalent.

3508 Machinery casings are to be made watertight and hose tested.

3509 A strong through beam is to be fitted at the deck level between the engine room and boiler room openings. A through beam should also be fitted in motor tugs when the machinery opening is of considerable length, and the casing stiffened by webs.

Panting and Strengthening of Bottom Forward

3510 The arrangements to resist panting, required by D 9, do not apply to tugs below 150 feet in length. In tugs 150 feet or more in length additional stiffening is also to be fitted in the 'tween decks throughout the panting region.

The requirements of D 8 for strengthening of bottom forward do not apply to tugs.

Equipment

3511 The regulations governing the assignment of the figure 1 for Equipment are defined in B 201 and B 202. The equipment is to be determined from Table 54 and associated notes. The equipment numeral is to be L (B+D) without addition for casings or other erections. (*See* D 3303.)

20th July, 1961

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The scantlings of rolled sections are based on the British Standards as revised in 1924; alternative sections will be considered by the Committee.

BAR KEELS AND STEMS

LENGTH L	BAR KEELS	STEMS
Feet	Inches	Inches
100	6×1	5×1
125	$6\frac{1}{2} \times 1\frac{1}{4}$	$5\frac{1}{4} \times 1\frac{1}{8}$
150	$7 \times 1\frac{1}{2}$	$5\frac{1}{2} \times 1\frac{1}{4}$
175	$7\frac{1}{4} \times 1\frac{3}{4}$	$5\frac{3}{4} \times 1\frac{1}{2}$
200	$7\frac{1}{2} \times 2$	$6 \times 1\frac{5}{8}$
225	$8 \times 2\frac{1}{8}$	$6\frac{1}{2} \times 1\frac{3}{4}$
250	$8\frac{1}{4} \times 2\frac{1}{4}$	$7 \times 1\frac{7}{8}$
275	$8\frac{1}{2} \times 2\frac{3}{8}$	$7\frac{1}{2} \times 2$
300	$9 \times 2\frac{1}{2}$	$8 \times 2\frac{1}{8}$
325	$9\frac{1}{2} \times 2\frac{5}{8}$	$8\frac{1}{4} \times 2\frac{1}{4}$
350	$10 \times 2\frac{3}{4}$	$8\frac{1}{2} \times 2\frac{3}{8}$
375		$8\frac{3}{4} \times 2\frac{1}{2}$
400		$9 \times 2\frac{5}{8}$
425		$9\frac{1}{2} \times 2\frac{3}{4}$
450		$10 \times 2\frac{7}{8}$
475		$10\frac{1}{2} \times 3$
500		11×3
525		$11\frac{1}{4} \times 3$
550		$11\frac{1}{2} \times 3\frac{1}{8}$
575		$11\frac{3}{4} \times 3\frac{1}{4}$
600		$12 \times 3\frac{3}{8}$
625		$12 \times 3\frac{1}{2}$
650		$12 \times 3\frac{3}{4}$

TABLE 2 STERNFRAMES WITH APERTURES

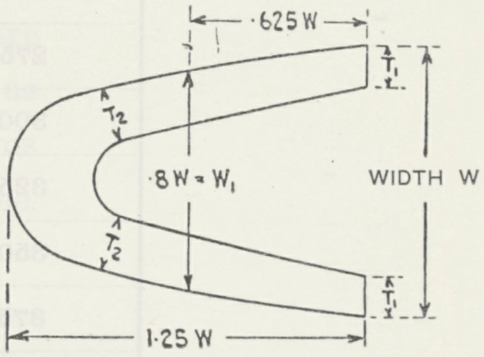
LENGTH L	WIDTH AND THICKNESS						
	SOLID		CASTINGS			BUILT	
	WIDTH		WIDTH	THICKNESS		WIDTH	THICKNESS
	Rectangular	Streamlined W	W	T_1	T_2	W	
1	2	3	4	5	6	7	8
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	2·5						
120	2·9						
140	3·3						
160	3·7						
180	4·1						
200	4·5	6·0	8·0	$\frac{3}{4}$	$1\frac{1}{4}$	10·0	·80
220	4·9	6·5	8·4	$\frac{7}{8}$	$1\frac{3}{8}$	10·4	·80
240	5·3	7·0	8·8	1	$1\frac{1}{2}$	10·8	·85
260	5·7	7·5	9·2	$1\frac{1}{8}$	$1\frac{5}{8}$	11·2	·85
280	6·1	8·0	9·5	$1\frac{1}{8}$	$1\frac{5}{8}$	11·6	·90
300	6·5	8·4	9·8	$1\frac{1}{4}$	$1\frac{3}{4}$	12·0	·90
320	6·9	8·8	10·1	$1\frac{1}{4}$	$1\frac{3}{4}$	12·4	·95
340	7·3	9·1	10·4	$1\frac{3}{8}$	$1\frac{7}{8}$	12·8	1·00
360	7·6	9·4	10·7	$1\frac{3}{8}$	2	13·2	1·05
380	7·9	9·7	11·0	$1\frac{1}{2}$	$2\frac{1}{8}$	13·6	1·10
400	8·2	10·0	11·3	$1\frac{1}{2}$	$2\frac{1}{4}$	14·0	1·15
420	8·5	10·2	11·6	$1\frac{5}{8}$	$2\frac{3}{8}$	14·4	1·20
440	8·7	10·4	11·9	$1\frac{5}{8}$	$2\frac{3}{8}$	14·8	1·25
460	8·9	10·6	12·1	$1\frac{3}{4}$	$2\frac{1}{2}$	15·2	1·25
480	9·1	10·8	12·3	$1\frac{3}{4}$	$2\frac{1}{2}$	15·6	1·30
500	9·3	11·0	12·5	$1\frac{3}{4}$	$2\frac{1}{2}$	16·0	1·30
520	9·5	11·2	12·7	$1\frac{7}{8}$	$2\frac{1}{2}$	16·4	1·35
540	9·7	11·4	13·0	$1\frac{7}{8}$	$2\frac{1}{2}$	16·8	1·35

NOTES.—TABLE 2

1. The dimensions given in the Table apply to both propeller post and rudder post.

2. The fore and aft dimension of the section is to be 25 per cent greater than its width as given in cols. 2, 3, 4 and 7 but is not to be less than 5 inches.

3. The width w given in cols. 3, 4 and 7 for streamlined solid, cast or built sternframes is the extreme width. The width w_1 at half the fore and aft dimension of the section is assumed to be 80 per cent of the extreme width. (*See* sketch.)



Where the section of sternframe adopted differs from that given above an equivalent section modulus is to be obtained.

4. The sole piece in way of the aperture is to be extended in an athwartship direction to a width 50 per cent greater than that given in col. 2 ; the vertical dimension is to be equal to the width in col. 2. If a rudder post is not fitted the scantlings of the sole piece will be specially considered.

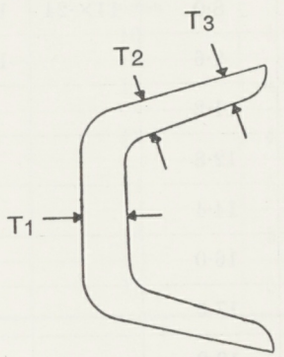
5. The boss of the propeller post is to have a finished thickness of metal round the bore equal to 60 per cent of the width given in col. 2.

6. The scantlings given in cols. 5, 6 and 8 are minima.

7. For scantlings of gudgeons *see* D 313.

STERNFRAMES OF TWIN SCREW SHIPS — TABLE 3

LENGTH L	SOLID	CASTING		
	WIDTH	THICKNESS		
		T_1	T_2	T_3
Feet	Inches	Inches	Inches	Inches
160	1·6			
180	1·8			
200	2·0			
220	2·2	$1\frac{1}{4}$	1	$\frac{3}{4}$
240	2·4	$1\frac{1}{4}$	1	$\frac{3}{4}$
260	2·6	$1\frac{1}{4}$	1	$\frac{3}{4}$
280	2·8	$1\frac{1}{2}$	1	$\frac{3}{4}$
300	3·0	$1\frac{1}{2}$	$1\frac{1}{4}$	1
320		$1\frac{3}{4}$	$1\frac{1}{4}$	1
340		$1\frac{3}{4}$	$1\frac{1}{4}$	1
360		2	$1\frac{1}{4}$	1
380		2	$1\frac{1}{2}$	$1\frac{1}{4}$
400		$2\frac{1}{4}$	$1\frac{1}{2}$	$1\frac{1}{4}$
420		$2\frac{1}{4}$	$1\frac{3}{4}$	$1\frac{1}{4}$
440		$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{4}$
460		$2\frac{1}{2}$	$1\frac{3}{4}$	$1\frac{1}{2}$
480		$2\frac{3}{4}$	2	$1\frac{1}{2}$
500		$2\frac{3}{4}$	2	$1\frac{1}{2}$
520		3	2	$1\frac{1}{2}$
540		$3\frac{1}{4}$	2	$1\frac{1}{2}$
560		$3\frac{1}{4}$	$2\frac{1}{4}$	$1\frac{3}{4}$
580		$3\frac{1}{2}$	$2\frac{1}{4}$	$1\frac{3}{4}$
600		$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$
620		$3\frac{3}{4}$	$2\frac{1}{2}$	$1\frac{3}{4}$
640		4	$2\frac{3}{4}$	$1\frac{3}{4}$



NOTES.—TABLE 3

1. Fore and aft dimensions of solid sternposts are to be three times the width.

2. The side flanges of cast steel sternposts are to have dimensions sufficient to take the shell connection.

TABLE 4 FLOORS IN SINGLE BOTTOMS

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	BREADTH B FEET									REVERSED FRAMES
			16	20	24	28	32	36	40	44	48	
Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
10	21	8·0	11×·24	12×·26	13×·26	15×·28	16×·30					3 × 2½×·30
12	21½	9·6		13×·26	14×·26	16×·28	18×·30					3 × 3 × ·34
14	22	11·2			15×·28	17×·30	19×·32	21×·34				3½×3 × ·38
16	22½	12·8				18×·30	20×·32	22×·34	24×·36			4 × 3 × ·40
18	23	14·4					21×·34	23×·36	25×·38	27×·40		5 × 3 × ·44
20	23½	16·0						24×·36	26×·38	28×·40	30×·42	5 × 3 × ·48
22	24	17·6							27×·38	29×·40	31×·42	6 × 3 × ·50
24	25	19·2							28×·40	30×·40	32×·42	6 × 3 × ·56

NOTES.—TABLE 4

1. **Corrections.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b depth of floors is to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of half an inch per foot of difference.

FOR FRAME SPACING.

If the spacing amidships is $\frac{\text{greater}}{\text{less}}$ than that given in the Table the thickness of the floors and of the reversed frames is to be $\frac{\text{increased}}{\text{reduced}}$ at the rate of ·01 inch and ·02 inch respectively for every two inches of difference.

2. **Increases in machinery spaces.**—In the engine room the floors are to be increased ·04 inch and in the boiler room the floors and the reversed frames are to be increased ·10 inch beyond the thicknesses given in the Table.

KEELSONS IN SINGLE BOTTOMS — TABLE 5

LENGTH L	CENTRE KEELSONS						SIDE KEELSONS	
	PLATE KEEL ANGLES		DOUBLE TOP ANGLES	THICKNESS OF VERTICAL PLATES AND FOUNDATION PLATES IF FITTED		BREADTH OF FOUNDATION PLATES IF FITTED	SINGLE TOP ANGLE	THICKNESS OF INTERCOSTAL PLATE
	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS	THROUGHOUT	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS			
1	2	3	4	5	6	7	8	9
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	3 × 3 × ·26	·26	3 × 3 × ·26	·30	·26	10	4 × 3 × ·28	·24
140	3 × 3 × ·32	·30	$3\frac{1}{2}$ × 3 × ·30	·34	·28	11	4 × 3 × ·30	·26
180	3 × 3 × ·36	·34	4 × 3 × ·32	·38	·32	12	4 × 3 × ·34	·30
220	$3\frac{1}{2}$ × $3\frac{1}{2}$ × ·40	·38	5 × 3 × ·32	·40	·34	14	5 × 3 × ·34	·32
260	$3\frac{1}{2}$ × $3\frac{1}{2}$ × ·42	·40	5 × 3 × ·38	·42	·36	16	5 × 3 × ·36	·36
300	$3\frac{1}{2}$ × $3\frac{1}{2}$ × ·44	·42	6 × $3\frac{1}{2}$ × ·40	·46	·38	18	5 × 3 × ·40	·38

KEELSONS IN TUGS

LENGTH L	CENTRE KEELSON ON TOP OF FLOORS WITH BAR KEEL		SIDE KEELSON ON TOP OF FLOORS
	SINGLE CHANNEL	DOUBLE BULB ANGLES	SINGLE ANGLE
Feet	Inches	Inches	Inches
100	8 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·40	5 × 3 × ·38	5 × 4 × ·36
120	9 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·44	5 × 3 × ·46	5 × 4 × ·38
140	10 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	6 × 3 × ·42	5 × 4 × ·40
160	12 × $3\frac{1}{2}$ × $3\frac{1}{2}$ × ·48	6 × 3 × ·48	5 × 4 × ·44

NOTES.—TABLE 5

In boiler rooms the thickness of the centre and side keelsons, foundation plates and angles not covered by cement is to be increased by ·10 inch.

TABLE 6 DOUBLE BOTTOMS

LENGTH L	FRAME SPACING AMIDSHIPS	CENTRE GIRDER					MARGIN PLATE		FLOOR PLATES, GIRDERS AND BRACKETS INSIDE TANK		
				THICKNESS			THICKNESS		THICKNESS		
		BASIC DRAUGHT d_b	HEIGHT ABOVE BASE LINE	FOR ·4L AMIDSHIPS	FOR ·1L FROM ENDS	IN BOILER ROOM	IN HOLDS AND ENGINE ROOM	IN BOILER ROOM	FLOORS IN HOLDS AND ENGINE ROOM. SIDE GIRDERS IN ENGINE ROOM	FLOORS AND SIDE GIRDERS IN BOILER ROOM	SIDE GIRDERS IN HOLDS
1	2	3	4	5	6	7	8	9	10	11	12
Feet	Inches	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
140	22	8·4	26	·32	·26	·42	·28	·38	·26	·36	·26
160	22½	9·6	26	·35	·29	·45	·31	·41	·27	·37	·26
180	23	10·8	27	·37	·31	·47	·33	·43	·28	·38	·27
200	23½	12·0	28	·39	·33	·49	·35	·45	·29	·39	·27
220	24	13·2	29	·40	·34	·50	·37	·47	·30	·40	·28
240	24½	14·4	30	·41	·35	·51	·39	·49	·31	·41	·29
260	25	15·6	31	·42	·36	·52	·40	·50	·32	·42	·30
280	25½	16·8	32	·44	·37	·54	·41	·51	·33	·43	·31
300	26	18·0	34	·45	·38	·55	·42	·52	·34	·44	·32
320	26½	19·2	35	·46	·39	·56	·43	·53	·35	·45	·33
340	27	20·4	37	·48	·40	·57	·44	·54	·36	·46	·34
360	27½	21·6	38	·49	·41	·58	·46	·55	·37	·47	·34
380	28	22·8	40	·50	·42	·59	·47	·56	·38	·48	·35
400	28½	24·0	42	·51	·43	·60	·49	·57	·39	·49	·36
420	29	25·2	43	·52	·44	·61	·50	·58	·40	·50	·36
440	29½	26·4	45	·53	·45	·62	·52	·59	·41	·51	·37
460	30	27·6	46	·54	·46	·62	·53	·60	·42	·52	·38
480	30½	28·8	48	·55	·47	·63	·55	·62	·43	·53	·39
500	31	30·0	49	·56	·48	·64	·56	·63	·44	·54	·40
520	31½	30·0	49	·57	·49	·65	·58	·65	·45	·55	·41
540	32	30·0	50	·58	·50	·66	·60	·66	·46	·55	·42
560	32½	30·0	51	·59	·51	·66	·62	·68	·47	·56	·43
580	33	30·0	51	·60	·52	·67	·64	·69	·48	·56	·44
600	33½	30·0	52	·61	·53	·67	·66	·71	·49	·57	·44
620	34	30·0	52	·62	·54	·68	·67	·72	·50	·57	·45
640	34½	30·0	53	·63	·55	·68	·69	·74	·51	·58	·46

NOTES.—TABLE 6

1. Corrections.

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b the height of the centre girder to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of half an inch for each foot of difference.

FOR FRAME SPACING.

If the spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in col. 2 the thickness of the floor and bracket plates, margin plate and inner bottom plating to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of ·01 inch for every two inches of difference.

If, in transversely framed ships, the spacing amidships exceeds the Table spacing by 4 inches or more the increase required will be specially considered.

The thickness of the inner bottom plating in the engine and boiler rooms and of the middle line strake throughout should not be corrected for frame spacing but is not to be less than the thickness derived from col. 16 after correction.

The thickness of watertight floors is to be ·08 inch greater than the thickness given in col. 10, but need not exceed ·54 inch.

INNER BOTTOM PLATING							ANGLE CONNECTIONS					LENGTH
MIDDLE LINE STRAKE EXCEPT IN BOILER ROOM			REMAINDER				ANGLES CONNECTING CENTRE GIRDER TO FLAT PLATE KEEL		ANGLES CONNECTING CENTRE GIRDER TO INNER BOTTOM		ANGLES CONNECTING MARGIN PLATE TO SHELL PLATING	L
BREADTH	THICKNESS		IN HOLDS		IN ENGINE ROOM	IN BOILER ROOM INCLUDING MIDDLE LINE STRAKE	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS	FOR ·4L AMIDSHIPS	THICKNESS FOR ·1L FROM ENDS		
	FOR ·4L AMIDSHIPS	FOR ·1L FROM ENDS	FOR ·4L AMIDSHIPS	FOR ·1L FROM ENDS								
13	14	15	16	17	18	19	20	21	22	23	24	25
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Feet
38	·28	·26	·26	·26	·30	·42	3 × 3 × ·32	·30	$2\frac{1}{2}\times2\frac{1}{2}\times$·28	·28	3 × 3 × ·30	140
39	·30	·28	·28	·27	·32	·44	3 × 3 × ·34	·32	$2\frac{1}{2}\times2\frac{1}{2}\times$·29	·29	3 × 3 × ·32	160
40	·32	·30	·30	·28	·34	·45	3 × 3 × ·36	·34	3 × 3 × ·30	·30	3 × 3 × ·34	180
41	·34	·31	·31	·29	·36	·47	3 × 3 × ·38	·36	3 × 3 × ·32	·31	3 × 3 × ·36	200
42	·36	·32	·32	·30	·38	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·40	·38	3 × 3 × ·34	·32	3 × 3 × ·38	220
43	·38	·33	·33	·31	·39	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·41	·39	3 × 3 × ·36	·34	3 × 3 × ·40	240
44	·40	·34	·34	·32	·40	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·42	·40	3 × 3 × ·38	·36	3 × 3 × ·42	260
45	·41	·35	·35	·32	·41	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·43	·41	3 × 3 × ·39	·37	3 × 3 × ·44	280
46	·42	·36	·36	·33	·42	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·44	·42	3 × 3 × ·40	·38	$3\frac{1}{2}\times3\frac{1}{2}\times$·44	300
47	·44	·37	·37	·33	·44	·53	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	·43	3 × 3 × ·41	·39	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	320
48	·45	·38	·38	·34	·45	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	·44	3 × 3 × ·42	·40	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	340
49	·47	·39	·39	·35	·47	·55	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	·45	3 × 3 × ·43	·41	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	360
50	·48	·40	·40	·36	·48	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	·46	3 × 3 × ·44	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	380
51	·49	·41	·41	·37	·49	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	·47	$3\frac{1}{2}\times3\frac{1}{2}\times$·45	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	400
52	·50	·42	·42	·38	·50	·57	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·46	·42	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	420
53	·51	·43	·43	·39	·51	·57	5 × 5 × ·52	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·47	·43	$3\frac{1}{2}\times3\frac{1}{2}\times$·52	440
54	·52	·44	·44	·40	·52	·58	5 × 5 × ·54	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·48	·44	$3\frac{1}{2}\times3\frac{1}{2}\times$·54	460
55	·54	·46	·46	·42	·54	·59	5 × 5 × ·55	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·49	·45	$3\frac{1}{2}\times3\frac{1}{2}\times$·55	480
56	·55	·47	·47	·43	·55	·60	5 × 5 × ·56	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·50	·46	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	500
57	·57	·49	·49	·45	·57	·61	5 × 5 × ·58	·53	$3\frac{1}{2}\times3\frac{1}{2}\times$·52	·47	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	520
58	·58	·50	·50	·46	·58	·62	5 × 5 × ·60	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·54	·48	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	540
59	·60	·52	·51	·47	·60	·63	5 × 5 × ·61	·55	$3\frac{1}{2}\times3\frac{1}{2}\times$·55	·49	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	560
60	·61	·53	·52	·48	·61	·64	5 × 5 × ·62	·56	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·50	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	580
61	·63	·55	·53	·49	·63	·65	5 × 5 × ·64	·58	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·51	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	600
62	·64	·56	·54	·50	·64	·66	5 × 5 × ·66	·60	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·52	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	620
63	·66	·58	·55	·51	·66	·67	5 × 5 × ·68	·62	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	·54	$3\frac{1}{2}\times3\frac{1}{2}\times$·56	640

NOTES.—TABLE 6 (*concluded*)

2. **Depth of margin plate** is not to be less than 80 per cent of the depth of centre girder corrected by note 1, where the length of the ship does not exceed 350 feet or 85 per cent where the length is 400 feet and above, with intermediate values in proportion. At the after end the depth may be reduced to 85 per cent of the depth amidships.

3. **Thickness of connecting angles not given in Table.**—The thickness of the vertical angles connecting intercostal girders to floors is not to be less than that of the intercostal plate. The thickness of the frames, reversed frames and other connecting angles is not to be less than the thickness of the floors.

4. **Width of faying flanges.**—For width of faying flanges for all angles, unless specified in the Table, *see* D 3202.

5. **In boiler rooms** angles not covered by cement are to be increased by ·10 inch in thickness.

6. **Oil fuel.**—For thickness of inner bottom plating when oil fuel is carried in the double bottom, *see* D 2020.

TABLE 7 BRACKET FLOORS

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS PER 1 FOOT DIFFERENCE BETWEEN d and d_b	UNSUPPORTED SPAN FEET 3	4	5	6	7	8	
Feet	Inches	Feet	Per cent	INCHES *Modulus—Inches*^{3}						
12	21½	9·6	*10·4*	3½×2½×·36 *1·55*	4 × 3 × ·47 *2·60*	5 × 3 × ·40 *3·30*				ANGLES
14	22	11·2	*9·0*	4 × 3 × ·34 *1·90*	5 × 3 × ·38 *3·15*	6 × 3 × ·33 *4·00*				
16	22½	12·8	*7·8*	4 × 3 × ·40 *2·20*	5 × 3 × ·44 *3·65*	5 × 3 × ·35 *4·65*	5 × 3 × ·40 *5·15*			
18	23	14·4	*7·0*	4 × 3 × ·46 *2·50*	6 × 3 × ·35 *4·20*	5 × 3 × ·42 *5·35*	5½×3 × ·37 *5·95*	6 × 3 × ·34 *6·80*	6 × 3 × ·46 *8·45*	
20	23½	16·0	*6·2*	5 × 3 × ·34 *2·85*	5 × 3 × ·36 *4·75*	5½×3 × ·38 *6·05*	6 × 3 × ·34 *6·80*	6 × 3 × ·40 *7·65*	7 × 3 × ·34 *9·60*	
22	24	17·6	*5·7*	5 × 3 × ·39 *3·25*	5 × 3 × ·42 *5·35*	6 × 3½×·34 *6·85*	6 × 3½×·39 *7·55*	6 × 3½×·48 *8·80*	7 × 3½×·41 *10·80*	
24	25	19·2	*5·2*	5 × 3 × ·44 *3·65*	5½×3 × ·39 *6·15*	6 × 3½×·40 *7·65*	6 × 3½×·46 *8·50*	7 × 3½×·35 *9·80*	7 × 3½×·49 *12·25*	
26	26	20·8	*4·8*	6 × 3 × ·35 *4·20*	6 × 3 × ·34 *6·80*	6 × 3½×·47 *8·65*	7 × 3½×·34 *9·65*	7 × 3½×·43 *11·15*	8 × 3½×·38 *13·85*	
28	27	22·4	*4·5*	5 × 3 × ·35 *4·65*	6 × 3 × ·40 *7·65*	7 × 3½×·34 *9·65*	7 × 3½×·41 *10·80*	7 × 3½×·50 *12·45*	8 × 3½×·44 *15·25*	BULB ANGLES
30	28	24·0	*4·2*	5 × 3 × ·40 *5·15*	6 × 3 × ·46 *8·45*	7 × 3½×·41 *10·80*	7 × 3½×·48 *12·05*	8 × 3½×·38 *13·85*	8 × 3½×·52 *17·15*	
32	29	25·6	*3·9*	5½×3 × ·35 *5·70*	*9·40*	7 × 3½×·47 *11·90*	8 × 3½×·35 *13·25*	8 × 3½×·44 *15·25*	9 × 3½×·40 *18·90*	
34	30	27·2	*3·7*	5½×3 × ·40 *6·25*	7 × 3 × ·38 *10·25*	*13·10*	8 × 3½×·41 *14·60*	8 × 3½×·50 *16·70*	9 × 3½×·47 *20·80*	
36	31	28·8	*3·5*	6 × 3½×·34 *6·85*	7 × 3½×·44 *11·30*	8 × 3½×·40 *14·35*	8 × 3½×·47 *16·00*	*18·30*	9 × 3½×·54 *22·70*	
38	32	30·0	*3·3*	6 × 3½×·38 *7·40*	7 × 3½×·49 *12·25*	8 × 3½×·45 *15·50*	8 × 3½×·54 *17·60*	9 × 3½×·43 *19·65*	*24·40*	
40	33	30·0	*3·3*	6 × 3½×·40 *7·65*	7 × 3½×·51 *12·65*	8 × 3½×·47 *16·00*	*18·15*	9 × 3½×·45 *20·20*	10 × 3½×·43 *25·15*	
42	34	30·0	*3·3*	6 × 3½×·42 *7·95*	*12·95*	8 × 3½×·49 *16·45*	9 × 3½×·39 *18·65*	9 × 3½×·48 *21·05*	10 × 3½×·46 *26·10*	
44	35	30·0	*3·3*	6 × 3½×·44 *8·20*	8 × 3½×·35 *13·25*	8 × 3½×·51 *16·95*	9 × 3½×·42 *19·40*	9 × 3½×·50 *21·60*	10 × 3½×·48 *26·80*	
46	36	30·0	*3·3*	6 × 3½×·46 *8·50*	8 × 3½×·37 *13·65*	8 × 3½×·53 *17·40*	9 × 3½×·44 *19·90*	9 × 3½×·52 *22·20*	10 × 3½×·50 *27·40*	
48	37	30·0	*3·3*	6 × 3½×·47 *8·65*	8 × 3½×·39 *14·10*	8 × 3½×·55 *17·85*	9 × 3½×·46 *20·50*	9 × 3½×·54 *22·70*	10 × 3½×·52 *28·10*	
50	38	30·0	*3·3*	6 × 3½×·49 *8·95*	8 × 3½×·41 *14·60*	*18·35*	9 × 3½×·48 *21·05*	9 × 3½×·56 *23·30*	10 × 3½×·54 *28·80*	

Section moduli above are given to nearest ·05

NOTES.—TABLE 7

1. **Scantlings.**—The bottom frames are to have scantlings determined from the Table; the modulus of the reversed frames may be 85 per cent of that of the bottom frames corrected as required below. For width of faying flanges *see* D 3202.

2. **Correction to modulus of frames.**

FOR DRAUGHT

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms,** frames, reversed frames, struts and angle connections are to be increased by ·10 inch in thickness.

4. Particulars of sections and moduli are given in Table 56.

DETAILS OF BRACKET FLOORS — TABLE 8

DEPTH OF FRAME		RIVETS IN BRACKETS		RIVETS IN EACH END OF VERTICAL BAR ON INTERCOSTAL GIRDER		VERTICAL STRUTS BETWEEN INTERCOSTAL GIRDER AND CENTRE LINE OR MARGIN PLATE	RIVETS IN EACH END OF VERTICAL STRUTS	
		NUMBER	DIAMETER	NUMBER	DIAMETER		NUMBER	DIAMETER
1		2	3	4	5	6	7	8
Inches			Inches		Inches	Inches		Inches
$3\frac{1}{2}$ and 4	ANGLES	4	$\frac{5}{8}$	2	$\frac{5}{8}$	$6 \times 3 \times \cdot 34$	2	$\frac{5}{8}$
5	ANGLES	5	$\frac{5}{8}$	2	$\frac{5}{8}$	$6 \times 3 \times \cdot 36$	3	$\frac{5}{8}$
6	ANGLES	5	$\frac{3}{4}$	2	$\frac{3}{4}$	$7 \times 3 \times 3 \times \cdot 36$	4	$\frac{3}{4}$
5 and $5\frac{1}{2}$	BULB ANGLES	5	$\frac{3}{4}$	2	$\frac{3}{4}$	$8 \times 3 \times 3 \times \cdot 36$	4	$\frac{3}{4}$
6	BULB ANGLES	6	$\frac{3}{4}$	2	$\frac{3}{4}$	$8 \times 3 \times 3 \times \cdot 40$	4	$\frac{7}{8}$
7	BULB ANGLES	7	$\frac{3}{4}$	3	$\frac{3}{4}$	$8 \times 3 \times 3 \times \cdot 40$	4	$\frac{7}{8}$
8	BULB ANGLES	8	$\frac{3}{4}$	4	$\frac{3}{4}$	$9 \times 3 \times 3 \times \cdot 44$	5	$\frac{7}{8}$
9	BULB ANGLES	8	$\frac{7}{8}$	4	$\frac{7}{8}$	$10 \times 3 \times 3 \times \cdot 44$	6	$\frac{7}{8}$
10 and above	BULB ANGLES	9	$\frac{7}{8}$	4	$\frac{7}{8}$	$10 \times 3 \times 3 \times \cdot 50$	6	$\frac{7}{8}$

CHANNELS

NOTES.—TABLE 8

1. **In boiler rooms** struts are to be increased by ·10 inch in thickness.

2. For scantlings of welded vertical struts *see* D 515.

TABLE 9 STIFFENERS TO WATERTIGHT FLOORS

Spaced 30 inches apart

DEPTH OF CENTRE GIRDER	HEIGHT OF OVERFLOW ABOVE INNER BOTTOM IN FEET						
	20	25	30	35	40	45	50
Inches	INCHES *Modulus—Inches*^{3}						
36	$3\frac{1}{2} \times 3 \times \cdot32$ *1·40*	$3\frac{1}{2} \times 3 \times \cdot40$ *1·75*	$4 \times 3 \times \cdot36$ *2·00*	$4 \times 3 \times \cdot43$ *2·35*	$4 \times 3 \times \cdot47$ *2·60*	$5 \times 3 \times \cdot36$ *3·00*	$5 \times 3 \times \cdot40$ *3·30*
42	$4 \times 3 \times \cdot34$ *1·90*	$4 \times 3 \times \cdot42$ *2·30*	$5 \times 3 \times \cdot32$ *2·70*	$5 \times 3 \times \cdot38$ *3·15*	$5 \times 3 \times \cdot44$ *3·65*	$5 \times 3 \times \cdot48$ *3·95*	$6 \times 3 \times \cdot38$ *4·55*
48	$4 \times 3 \times \cdot47$ *2·60*	$5 \times 3 \times \cdot38$ *3·15*	$5 \times 3 \times \cdot44$ *3·65*	$6 \times 3 \times \cdot36$ *4·30*	$6 \times 3 \times \cdot40$ *4·75*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$5\frac{1}{2} \times 3 \times \cdot40$ *6·25*
54	$5 \times 3 \times \cdot40$ *3·30*	$5 \times 3 \times \cdot48$ *3·95*	$6 \times 3 \times \cdot40$ *4·75*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$5\frac{1}{2} \times 3 \times \cdot40$ *6·25*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot40$ *7·65*
60	$5 \times 3 \times \cdot48$ *3·95*	$6 \times 3 \times \cdot42$ *5·00*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot40$ *7·65*	$6 \times 3 \times \cdot46$ *8·45*	$6 \times 3 \times \cdot52$ *9·30*
66	$6 \times 3 \times \cdot42$ *5·00*	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot46$ *8·45*	$6 \times 3 \times \cdot52$ *9·30*	$7 \times 3 \times \cdot40$ *10·60*	$7 \times 3 \times \cdot46$ *11·65*
72	$5\frac{1}{2} \times 3 \times \cdot36$ *5·80*	$6 \times 3 \times \cdot36$ *7·10*	$6 \times 3 \times \cdot46$ *8·45*	$7 \times 3 \times \cdot36$ *9·95*	$7 \times 3 \times \cdot42$ *10·95*	$7 \times 3 \times \cdot49$ *12·25*	$8 \times 3 \times \cdot38$ *13·85*

ANGLES (36, 42, 48, 54, 60, 66) — BULB ANGLES (72)

ANGLES (36, 42) — BULB ANGLES (48, 54, 60, 66, 72)

Section moduli above are given to nearest ·05

NOTES.—TABLE 9

1. **In boiler rooms** stiffeners are to be increased by ·10 inch in thickness.

2. Particulars of sections and moduli are given in Table 56.

LENGTH L	SPACING OF LONGITUDINALS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS PER 1 FOOT DIFFERENCE BETWEEN d and d_b*	UNSUPPORTED SPAN FEET				
				4	5	6	7	8
Feet	Inches	Feet	Per cent	INCHES *Modulus—Inches*				
160	27½	9·6	*10·4*	5 × 3 × ·41 *3·40*	6 × 3 × ·35 *4·20*	5 × 3 × ·39 *5·05*	5½ × 3 × ·36 *5·80*	6 × 3 × ·33 *6·65*
180	28	10·8	*9·2*	6 × 3 × ·33 *4·00*	5 × 3 × ·37 *4·85*	5½ × 3 × ·37 *5·90*	6 × 3 × ·34 *6·80*	6 × 3 × ·40 *7·65*
200	28½	12·0	*8·3*	5 × 3 × ·34 *4·55*	5½ × 3 × ·34 *5·60*	6 × 3 × ·33 *6·65*	6 × 3 × ·40 *7·65*	6 × 3 × ·48 *8·75*
220	29	13·2	*7·6*	5 × 3 × ·41 *5·25*	5½ × 3 × ·41 *6·40*	6 × 3 × ·39 *7·50*	6 × 3 × ·48 *8·75*	7 × 3 × ·36 *9·95*
240	29½	14·4	*6·9*	5½ × 3 × ·37 *5·95*	6 × 3 × ·37 *7·25*	6 × 3 × ·46 *8·45*	7 × 3 × ·35 *9·80*	7 × 3 × ·43 *11·15*
260	30	15·6	*6·4*	6 × 3 × ·33 *6·65*	6 × 3 × ·43 *8·05*	6 × 3 × ·53 *9·45*	7 × 3 × ·42 *10·95*	7 × 3 × ·50 *12·40*
280	30½	16·8	*6·0*	6 × 3 × ·38 *7·35*	6 × 3 × ·50 *9·00*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·57 *13·70*
300	31	18·0	*5·6*	6 × 3½ × ·44 *8·20*	7 × 3½ × ·36 *9·95*	7 × 3½ × ·45 *11·50*	8 × 3½ × ·35 *13·25*	8 × 3½ × ·43 *15·05*
320	31½	19·2	*5·2*	6 × 3½ × ·50 *9·05*	7 × 3½ × ·42 *10·95*	7 × 3½ × ·51 *12·65*	8 × 3½ × ·41 *14·60*	8 × 3½ × ·49 *16·45*
340	32	20·4	*4·9*	7 × 3½ × ·37 *10·10*	7 × 3½ × ·48 *12·05*	8 × 3½ × ·38 *13·85*	8 × 3½ × ·46 *15·75*	8 × 3½ × ·55 *17·85*
360	32½	21·6	*4·6*	7 × 3½ × ·43 *11·15*	*13·00*	8 × 3½ × ·44 *15·25*	8 × 3½ × ·52 *17·15*	9 × 3½ × ·42 *19·40*
380	33	22·8	*4·4*	7 × 3½ × ·48 *12·05*	8 × 3½ × ·40 *14·35*	8 × 3½ × ·49 *16·45*	*18·70*	9 × 3½ × ·48 *21·05*
400	33½	24·0	*4·2*	*13·20*	8 × 3½ × ·45 *15·50*	8 × 3½ × ·55 *17·85*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·54 *22·70*
420	34	25·2	*4·0*	8 × 3½ × ·40 *14·35*	8 × 3½ × ·50 *16·70*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	*24·45*
440	34½	26·4	*3·8*	8 × 3½ × ·46 *15·75*	8 × 3½ × ·56 *18·05*	9 × 3½ × ·47 *20·80*	9 × 3½ × ·57 *23·60*	10 × 3½ × ·46 *26·10*
460	35	27·6	*3·6*	8 × 3½ × ·51 *16·95*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·52 *28·10*
480	35½	28·8	*3·4*	*18·50*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·58 *30·10*
500	36	30·0	*3·3*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·54 *28·80*	*32·00*

ANGLES · BULB ANGLES

Section moduli above are given to nearest ·05

NOTES.—TABLE 10

1. **Scantlings.**—The bottom longitudinals are to have scantlings determined from the Table; the modulus of the inner bottom longitudinals may be 85 per cent of that of the bottom longitudinals corrected as required below. For width of faying flanges *see* D 3202.

2. **Corrections to modulus of bottom longitudinals.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR SPACING OF LONGITUDINALS.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion.

3. **In boiler rooms,** longitudinals, struts and angle connections are to be increased by ·10 inch in thickness.

4. Particulars of sections and moduli are given in Table 56.

TABLE 11

(*SEE CONTINUATION*)

ATTACHMENT OF TANK SIDE BRACKET

DEPTH D	FRAME SPACING AMIDSHIPS	HEIGHT OF TANK SIDE BRACKET ABOVE BASE	FRAME											
			4 INCH ORDINARY ANGLE				5 INCH ORDINARY ANGLE				6 INCH ORDINARY ANGLE			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE		
				ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION
Feet	Inches	Inches	Inches				Inches				Inches			
10	21	28	·26	5†	—	5†								
12	21½	32	·27	5†	—	5†	·28	5†	—	5†	·29	5*	—	5†
14	22	36	·28	5†	—	5†	·29	5*	—	5†	·30	5*	—	5†
16	22½	40	·28	5*	—	5†	·29	5*	—	5*	·31	5*	—	5*
18	23	44									·32	6*	—	5*
20	23½	48									·33	6*	—	5*
22	24	52												
24	25	55												
26	26	58												
28	27	61												
30	28	64												
32	29	67												
34	30	70												
36	31	72												
38	32	74												
40	33	76												
42	34	78												
44	35	79												
46	36	81												
48	37	83												
50	38	84												

† Rivets $\frac{5}{8}$ inch diameter * Rivets $\frac{3}{4}$ inch diameter Remainder $\frac{7}{8}$ inch diameter

For notes see pages 82 & 83

TABLE 11
(SEE CONTINUATION)

FRAME															DEPTH D
6 INCH BULB ANGLE				7 INCH BULB ANGLE				8 INCH BULB ANGLE				9 INCH BULB ANGLE			
HICKNESS OF TANK SIDE RACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			
	ANGLE TO MARGIN	GUSSET	FRAME CONNEC-TION		ANGLE TO MARGIN	GUSSET	FRAME CONNEC-TION		ANGLE TO MARGIN	GUSSET	FRAME CONNEC-TION		ANGLE TO MARGIN	GUSSET	FRAME CONNEC-TION	
Inches				Inches				Inches				Inches				Feet
																10
																12
·31	6*	—	5*													14
·32	6*	—	6*													16
·32	6*	—	6*	·33	6*	—	6*	·34	6*	1*	6*					18
·34	6*	—	6*	·34	6*	1*	6*	·34	6*	2*	7*					20
·35	6*	1*	6*	·35	6*	2*	6*	·35	5	1	5	·36	6	2	7	22
·36	6*	1*	6*	·36	6*	2*	6*	·36	5	2	6	·38	6	3	7	24
·38	6*	2*	6*	·38	5	1	5	·38	5	2	6	·40	6	4	8	26
				·40	5	2	5	·40	6	2	6	·41	7	4	8	28
				·41	6	2	6	·41	6	3	7	·42	7	4	8	30
								·42	7	3	7	·43	7	4	8	32
								·43	7	3	7	·44	8	4	8	34
								·44	7	4	8	·44	8	5	8	36
												·45	8	6	8	38
												·46	8	6	9	40
												·47	8	7	9	42
												·47	8	7	9	44
																46
																48
																50

† Rivets $\frac{5}{8}$ inch diameter * Rivets $\frac{3}{4}$ inch diameter Remainder $\frac{7}{8}$ inch diameter

For notes see pages 82 & 83

TABLE 11
(CONCLUDED)

ATTACHMENT OF TANK SIDE BRACKETS

DEPTH D	FRAME SPACING AMIDSHIPS	HEIGHT OF TANK SIDE BRACKET ABOVE BASE	FRAME											
			10 INCH BULB ANGLE				11 INCH BULB ANGLE				12 INCH BULB ANGLE			
			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE		
				ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTIO
Feet	Inches	Inches	Inches				Inches				Inches			
10	21	28												
12	21½	32												
14	22	36												
16	22½	40												
18	23	44												
20	23½	48												
22	24	52	·38	6	4	8								
24	25	55	·40	6	5	8								
26	26	58	·41	7	6	8	·42	7	6	8				
28	27	61	·42	7	6	8	·43	7	7	8	·43	8	8	9
30	28	64	·43	8	6	9	·44	8	7	9	·44	9	8	10
32	29	67	·44	8	6	9	·44	8	7	9	·45	9	8	10
34	30	70	·45	8	6	9	·45	8	7	9	·46	9	8	10
36	31	72	·45	8	6	9	·46	9	7	10	·47	9	8	10
38	32	74	·46	8	7	9	·47	9	7	10	·48	9	8	10
40	33	76	·47	8	7	10	·47	9	8	11	·48	9	9	11
42	34	78	·48	8	8	10	·48	9	9	11	·49	10	9	11
44	35	79	·48	9	8	10	·48	9	9	11	·49	10	9	12
46	36	81	·48	9	8	10	·49	9	9	11	·50	10	9	12
48	37	83	·49	9	8	10	·50	10	9	11	·50	11	9	12
50	38	84					·50	10	9	11	·50	11	9	12

Rivets $\frac{7}{8}$ inch diameter

NOTES.—TABLE 11

1. **Corrections.**—If the frame spacing amidships is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than that given in the Table, the thickness of the tank side brackets is to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ at the rate of ·01 inch for every two inches of difference.

2. The height of tank side brackets is to be measured at the inner edge of the frame.

TABLE 11
(CONCLUDED)

FRAME												DEPTH D
13½ INCH BULB ANGLE				15 INCH CHANNEL				17 INCH CHANNEL				
THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			THICKNESS OF TANK SIDE BRACKET AND GUSSET	NUMBER AND DIAMETER OF RIVETS PER FRAME SPACE			
	ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION		ANGLE TO MARGIN	GUSSET	FRAME CONNECTION	
Inches				Inches				Inches				Feet
												10
												12
												14
												16
												18
												20
												22
												24
												26
·44	9	8	10	·45	9	9	12	·46	10	9	14	28
·45	10	8	10	·46	10	9	12	·47	11	9	14	30
·46	10	8	11	·46	10	9	12	·47	11	9	14	32
·47	10	8	11	·47	10	9	12	·48	11	10	14	34
·48	10	8	11	·48	10	9	12	·49	11	10	14	36
·49	10	8	11	·49	11	9	12	·50	11	10	14	38
·50	10	9	11	·50	11	10	12	·51	12	11	15	40
·51	11	9	12	·51	11	10	13	·52	12	11	15	42
·51	11	9	12	·52	12	10	13	·52	12	11	15	44
·51	11	9	12	·52	12	10	13	·52	13	11	15	46
·52	12	10	12	·52	13	11	13	·52	14	12	15	48
·52	12	10	12	·52	13	11	13	·52	14	12	15	50

Rivets $\frac{7}{8}$ inch diameter

NOTES.—TABLE 11 *(continued)*

3. The angles connecting the tank side brackets to the margin plate are to have the same thickness as the brackets.

4. **In boiler rooms,** the tank side brackets, gussets and connecting angles are to be increased by ·10 inch in thickness.

5. For increases in way of panting region *see* D 906.

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	FRAMING IN PEAKS	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET								
					8	10	12	13	14	15	16	17	18
Feet	Inches	Feet	INCHES Modulus—Inches³	Per cent	< INCHES Modulus—Inches³ >								
10	21	8·0	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot35$ 1·50	15·0	$3\frac{1}{2}\times3\times\cdot29$ 1·25	$3\frac{1}{2}\times3\times\cdot35$ 1·50	$3\frac{1}{2}\times3\times\cdot42$ 1·80	$4\times3\times\cdot36$ 2·00	$4\times3\times\cdot40$ 2·20				
11	$21\frac{1}{4}$	8·8	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot41$ 1·75	14·0	$3\frac{1}{2}\times3\times\cdot32$ 1·40	$3\frac{1}{2}\times3\times\cdot40$ 1·75	$4\times3\times\cdot40$ 2·20	$4\times3\times\cdot45$ 2·45	$5\times3\times\cdot32$ 2·70	$5\times3\times\cdot36$ 3·00			
12	$21\frac{1}{2}$	9·6	$4\times3\times\cdot36$ 2·00	13·0	$3\frac{1}{2}\times3\times\cdot37$ 1·60	$4\times3\times\cdot37$ 2·05	$5\times3\times\cdot31$ 2·60	$5\times3\times\cdot35$ 2·95	$5\times3\times\cdot39$ 3·25	$5\times3\times\cdot44$ 3·65	$6\times3\times\cdot33$ 4·00		
13	$21\frac{3}{4}$	10·4	$4\times3\times\cdot39$ 2·70	12·0		$4\times3\times\cdot44$ 2·40	$5\times3\times\cdot36$ 3·00	$5\times3\times\cdot41$ 3·40	$5\times3\times\cdot46$ 3·80	$6\times3\times\cdot35$ 4·20	$6\times3\times\cdot39$ 4·65	$6\times3\times\cdot44$ 5·20	
14	22	11·2	$5\times3\times\cdot41$ 3·40	11·0		$5\times3\times\cdot34$ 2·85	$5\times3\times\cdot43$ 3·55	$6\times3\times\cdot33$ 4·00	$6\times3\times\cdot37$ 4·40	$6\times3\times\cdot41$ 4·85	$6\times3\times\cdot46$ 5·40	$6\times3\times\cdot51$ 6·00	$5\frac{1}{2}\times3\times\cdot42$ 6·50
15	$22\frac{1}{4}$	12·0	$5\times3\times\cdot43$ 3·60	10·5		$5\times3\times\cdot40$ 3·30	$6\times3\times\cdot34$ 4·10	$6\times3\times\cdot38$ 4·55	$6\times3\times\cdot43$ 5·10	$6\times3\times\cdot48$ 5·65	$5\frac{1}{2}\times3\times\cdot39$ 6·15	$6\times3\times\cdot34$ 6·80	$6\times3\times\cdot38$ 7·35
16	$22\frac{1}{2}$	12·8	$5\times3\times\cdot46$ 3·80	10·0				$6\times3\times\cdot44$ 5·20	$6\times3\times\cdot49$ 5·75	$5\frac{1}{2}\times3\times\cdot40$ 6·25	$6\times3\times\cdot35$ 6·95	$6\times3\times\cdot39$ 7·50	$6\times3\times\cdot44$ 8·20
17	$22\frac{3}{4}$	13·6	$6\times3\times\cdot34$ 4·10	9·5					$6\times3\times\cdot32$ 6·50	$6\times3\times\cdot36$ 7·10	$6\times3\times\cdot41$ 7·80	$6\times3\times\cdot46$ 8·45	$6\times3\times\cdot51$ 9·15
18	23	14·4	$6\times3\times\cdot36$ 4·30	9·0	$6\times3\times\cdot50$ 5·85	$5\frac{1}{2}\times3\times\cdot38$ 6·05	$5\frac{1}{2}\times3\times\cdot42$ 6·50	$6\times3\times\cdot35$ 6·95	$6\times3\times\cdot39$ 7·50	$6\times3\times\cdot43$ 8·05	$6\times3\times\cdot48$ 8·75	$7\times3\times\cdot33$ 9·45	$7\times3\times\cdot39$ 10·45
19	$23\frac{1}{4}$	15·2	$6\times3\times\cdot40$ 4·75	8·5	$5\frac{1}{2}\times3\times\cdot40$ 6·25	$5\frac{1}{2}\times3\times\cdot43$ 6·60	$6\times3\times\cdot38$ 7·35	$6\times3\times\cdot41$ 7·80	$6\times3\times\cdot46$ 8·45	$6\times3\times\cdot51$ 9·15	$7\times3\times\cdot36$ 9·95	$7\times3\times\cdot41$ 10·80	$7\times3\times\cdot47$ 11·85
20	$23\frac{1}{2}$	16·0	$6\times3\times\cdot43$ 5·10	8·0	$6\times3\times\cdot34$ 6·80	$6\times3\times\cdot37$ 7·25	$6\times3\times\cdot44$ 8·20	$6\times3\times\cdot48$ 8·75	9·50	$7\times3\times\cdot38$ 10·25	$7\times3\times\cdot43$ 11·15	$7\times3\times\cdot49$ 12·25	13·35
21	$23\frac{3}{4}$	16·8	$5\frac{1}{2}\times3\times\cdot34$ 5·60	7·5	$6\times3\times\cdot38$ 7·35	$6\times3\times\cdot42$ 7·90	$6\times3\times\cdot48$ 8·75	9·35	$7\times3\times\cdot37$ 10·10	$7\times3\times\cdot42$ 10·95	$7\times3\times\cdot48$ 12·05	12·95	$8\times3\times\cdot39$ 14·10
22	24	17·6	$5\frac{1}{2}\times3\times\cdot39$ 6·15	7·0	$6\times3\times\cdot42$ 7·90	$6\times3\times\cdot46$ 8·45	9·50	$7\times3\times\cdot37$ 10·10	$7\times3\times\cdot42$ 10·95	$7\times3\times\cdot47$ 11·85	13·00	$8\times3\times\cdot38$ 13·85	$8\times3\times\cdot45$ 15·45
23	$24\frac{1}{2}$	18·4	$6\times3\times\cdot33$ 6·65	6·6	$6\times3\times\cdot47$ 8·60	9·20	$7\times3\times\cdot38$ 10·25	$7\times3\times\cdot42$ 10·95	$7\times3\times\cdot47$ 11·85	12·75	$8\times3\times\cdot38$ 13·85	$8\times3\times\cdot43$ 15·00	$8\times3\times\cdot49$ 16·35
24	25	19·2	$6\times3\times\cdot37$ 7·25	6·3	9·30	$7\times3\times\cdot36$ 9·95	$7\times3\times\cdot42$ 10·95	$7\times3\times\cdot47$ 11·85	12·70	$8\times3\times\cdot37$ 13·65	$8\times3\times\cdot42$ 14·75	$8\times3\times\cdot48$ 16·10	17·40
25	$25\frac{1}{2}$	20·0	$6\times3\times\cdot42$ 7·90	6·0	$7\times3\times\cdot37$ 10·10	$7\times3\times\cdot41$ 10·80	$7\times3\times\cdot47$ 11·85	12·65	$8\times3\times\cdot37$ 13·65	$8\times3\times\cdot41$ 14·55	$8\times3\times\cdot47$ 15·90	$8\times3\frac{1}{2}\times\cdot51$ 16·95	18·55
26	26	20·8	$6\times3\times\cdot46$ 8·45	5·8	$7\times3\times\cdot42$ 10·95	$7\times3\times\cdot45$ 11·50	$7\times3\times\cdot52$ 12·80	13·60	$8\times3\times\cdot41$ 14·55	$8\times3\times\cdot46$ 15·65	$8\times3\times\cdot51$ 16·85	18·15	$9\times3\frac{1}{2}\times\cdot43$ 19·65
27	$26\frac{1}{2}$	21·6	$6\times3\times\cdot52$ 9·30	5·6	$7\times3\times\cdot47$ 11·85	$7\times3\times\cdot50$ 12·40	13·70	$8\times3\times\cdot41$ 14·55	$8\times3\times\cdot46$ 15·65	$8\times3\times\cdot50$ 16·60	18·00	$9\times3\frac{1}{2}\times\cdot42$ 19·40	$9\times3\frac{1}{2}\times\cdot48$ 21·05
28	27	22·4	$7\times3\times\cdot36$ 9·95	5·4	$7\times3\times\cdot51$ 12·60	13·30	$8\times3\times\cdot42$ 14·75	$8\times3\times\cdot46$ 15·65	$8\times3\frac{1}{2}\times\cdot49$ 16·45	17·75	$9\times3\frac{1}{2}\times\cdot41$ 19·15	$9\times3\frac{1}{2}\times\cdot47$ 20·80	$9\times3\frac{1}{2}\times\cdot53$ 22·45
29	$27\frac{1}{2}$	23·2	$7\times3\times\cdot41$ 10·80	5·2	13·75	$8\times3\times\cdot40$ 14·30	$8\times3\times\cdot46$ 15·65	$8\times3\times\cdot50$ 16·60	17·75	$9\times3\frac{1}{2}\times\cdot40$ 18·90	$9\times3\frac{1}{2}\times\cdot46$ 20·50	$9\times3\frac{1}{2}\times\cdot52$ 22·20	24·00
30	28	24·0	$7\times3\times\cdot45$ 11·50	5·0	$8\times3\times\cdot42$ 14·75	$8\times3\times\cdot45$ 15·45	$8\times3\frac{1}{2}\times\cdot50$ 16·70	17·75	$9\times3\frac{1}{2}\times\cdot40$ 18·90	$9\times3\frac{1}{2}\times\cdot45$ 20·20	$9\times3\frac{1}{2}\times\cdot51$ 21·90	$9\times3\frac{1}{2}\times\cdot57$ 23·60	$10\times3\frac{1}{2}\times\cdot45$ 25·80

ANGLES (rows 10–15) / BULB ANGLES (rows 16–30)

Section moduli above are given to nearest ·05

For notes see page 89

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b*	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
				19	20	21	22	23	24	25	26
Feet	Inches	Feet	Per cent	INCHES — *Modulus—Inches*³							
10	21	8·0	*15·0*								
11	21¼	8·8	*14·0*								
12	21½	9·6	*13·0*								
13	21¾	10·4	*12·0*								
14	22	11·2	*11·0*								
15	22¼	12·0	*10·5*	6 × 3 × ·43 *8·05*							
16	22½	12·8	*10·0*	6 × 3 × ·50 *9·00*	7 × 3 × ·35 *9·80*						
17	22¾	13·6	*9·5*	7 × 3 × ·37 *10·10*	7 × 3 × ·43 *11·15*	7 × 3 × ·48 *12·05*					
18	23	14·4	*9·0*	7 × 3 × ·45 *11·50*	7 × 3 × ·50 *12·40*	8 × 3 × ·37 *13·65*	8 × 3 × ·42 *14·75*				
19	23¼	15·2	*8·5*	7 × 3 × ·52 *12·80*	8 × 3 × ·39 *14·10*	8 × 3 × ·44 *15·20*	8 × 3 × ·50 *16·60*	8 × 3 × ·55 *17·80*			
20	23½	16·0	*8·0*	8 × 3 × ·41 *14·55*	8 × 3 × ·46 *15·65*	8 × 3 × ·52 *17·10*	*18·50*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*		
21	23¾	16·8	*7·5*	8 × 3 × ·46 *15·65*	8 × 3 × ·51 *16·85*	*18·30*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	*24·70*	
22	24	17·6	*7·0*	8 × 3 × ·50 *16·60*	*18·00*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·55 *23·00*	*24·85*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·52 *28·10*
23	24½	18·4	*6·6*	*17·75*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·48 *21·05*	9 × 3½ × ·54 *22·70*	*24·55*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·59 *30·45*
24	25	19·2	*6·3*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·52 *22·20*	*24·10*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *30·45*	*32·55*
25	25½	20·0	*6·0*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·58 *23·85*	*25·60*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·58 *30·10*	*32·25*	11 × 3½ × ·52 *34·55*
26	26	20·8	*5·8*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·56 *23·30*	*25·25*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·56 *29·45*	*31·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·57 *36·60*
27	26½	21·6	*5·6*	9 × 3½ × ·55 *23·00*	*24·75*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	*31·40*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·63 *39·00*
28	27	22·4	*5·4*	*24·50*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·54 *28·80*	*30·80*	11 × 3½ × ·49 *33·45*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·50 *41·20*
29	27½	23·2	*5·2*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *80·45*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·49 *40·75*	12 × 3½ × ·55 *43·55*
30	28	24·0	*5·0*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	*40·40*	12 × 3½ × ·54 *43·05*	12 × 3½ × ·61 *46·40*

ANGLES

BULB ANGLES

Section moduli above are given to nearest ·05

For notes see page 89

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b*		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					27	28	29	30	31	32	33	34
Feet	Inches	Feet	Per cent		INCHES *Modulus—Inches³*							
10	21	8·0	*15·0*	ANGLES								
11	$21\frac{1}{4}$	8·8	*14·0*									
12	$21\frac{1}{2}$	9·6	*13·0*									
13	$21\frac{3}{4}$	10·4	*12·0*									
14	22	11·2	*11·0*	BULB ANGLES								
15	$22\frac{1}{4}$	12·0	*10·5*									
16	$22\frac{1}{2}$	12·8	*10·0*									
17	$22\frac{3}{4}$	13·6	*9·5*									
18	23	14·4	*9·0*									
19	$23\frac{1}{4}$	15·2	*8·5*									
20	$23\frac{1}{2}$	16·0	*8·0*									
21	$23\frac{3}{4}$	16·8	*7·5*									
22	24	17·6	*7·0*									
23	$24\frac{1}{2}$	18·4	*6·6*		*32·65*							
24	25	19·2	*6·3*		$11\times3\frac{1}{2}\times\cdot52$ *34·55*	$11\times3\frac{1}{2}\times\cdot58$ *37·00*						
25	$25\frac{1}{2}$	20·0	*6·0*		$11\times3\frac{1}{2}\times\cdot58$ *37·00*	$11\times3\frac{1}{2}\times\cdot64$ *39·40*	$12\times3\frac{1}{2}\times\cdot51$ *41·65*	$12\times3\frac{1}{2}\times\cdot56$ *44·00*				
26	26	20·8	*5·8*		$11\times3\frac{1}{2}\times\cdot64$ *39·40*	$12\times3\frac{1}{2}\times\cdot51$ *41·65*	$12\times3\frac{1}{2}\times\cdot56$ *44·00*	$12\times3\frac{1}{2}\times\cdot62$ *46·85*	$12\times4\times4\times\cdot56$ *49·40*			
27	$26\frac{1}{2}$	21·6	*5·6*		$12\times3\frac{1}{2}\times\cdot51$ *41·65*	$12\times3\frac{1}{2}\times\cdot56$ *44·00*	$12\times3\frac{1}{2}\times\cdot62$ *46·85*	$12\times4\times4\times\cdot57$ *49·80*	$12\times4\times4\times\cdot63$ *52·20*	*55·00*		
28	27	22·4	*5·4*		$12\times3\frac{1}{2}\times\cdot56$ *44·00*	$12\times3\frac{1}{2}\times\cdot62$ *46·85*	$12\times4\times4\times\cdot57$ *49·80*	$12\times4\times4\times\cdot64$ *52·60*	*55·30*	*58·15*	$15\times4\times4\times\cdot42$ *60·95*	
29	$27\frac{1}{2}$	23·2	*5·2*		$12\times3\frac{1}{2}\times\cdot62$ *46·85*	$12\times4\times4\times\cdot57$ *49·80*	$12\times4\times4\times\cdot64$ *52·60*	*55·55*	*58·55*	$15\times4\times4\times\cdot43$ *61·55*	$15\times4\times4\times\cdot48$ *64·60*	$15\times4\times4\times\cdot53$ *67·65*
30	28	24·0	*5·0*	CH.	$12\times4\times4\times\cdot56$ *49·40*	$12\times4\times4\times\cdot64$ *52·60*	*55·50*	*58·75*	$15\times4\times4\times\cdot44$ *62·15*	$15\times4\times4\times\cdot49$ *65·25*	$15\times4\times4\times\cdot54$ *68·25*	$15\times4\times4\times\cdot60$ *71·80*

Section moduli above are given to nearest ·05

For notes see page 89

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	FRAMING IN PEAKS	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET								
					8	10	12	13	14	15	16	17	18
Feet	Inches	Feet	INCHES *Modulus—Inches³*	Per cent	INCHES *Modulus—Inches³*								
31	28½	24·8	7 × 3 × ·51 *12·60*	*4·8*	8 × 3½ × ·47 *16·00*	8 × 3½ × ·50 *16·70*	*17·80*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·56 *23·30*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·49 *27·10*
32	29	25·6	8 × 3 × ·38 *13·85*	*4·6*	8 × 3½ × ·51 *16·95*	*17·70*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·54 *28·80*
33	29½	26·4	8 × 3 × ·44 *15·20*	*4·4*	*18·25*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·45 *25·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·59 *30·45*
34	30	27·2	8 × 3 × ·50 *16·60*	*4·3*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·45 *31·95*
35	30½	28·0	8 × 3 × ·55 *17·80*	*4·2*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·49 *33·45*
36	31	28·8	9 × 3½ × ·41 *19·15*	*4·1*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*
37	31½	29·4	9 × 3½ × ·45 *20·20*	*4·0*	9 × 3½ × ·56 *23·30*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·57 *29·75*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·57 *36·60*
38	32	30·0	*21·20*	*4·0*	9 × 3½ × ·59 *24·15*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*
39	32½	30·0	*21·40*	*4·0*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·62 *31·45*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·63 *39·00*
40	33	30·0	9 × 3½ × ·50 *21·60*	*4·0*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·56 *29·45*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·47 *39·90*
41	33½	30·0	*21·80*	*4·0*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·49 *33·45*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·50 *41·20*
42	34	30·0	*22·00*	*4·0*	10 × 3½ × ·49 *27·10*	10 × 3½ × ·52 *28·10*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·61 *31·15*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·52 *42·10*
43	34½	30·0	9 × 3½ × ·52 *22·20*	*4·0*	10 × 3½ × ·51 *27·75*	10 × 3½ × ·55 *29·15*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·55 *43·55*
44	35	30·0	*22·40*	*4·0*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·57 *29·80*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·50 *41·20*	12 × 3½ × ·57 *44·50*
45	35½	30·0	*22·60*	*4·0*	10 × 3½ × ·56 *29·45*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·47 *32·50*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·59 *45·45*
46	36	30·0	*22·80*	*4·0*	10 × 3½ × ·58 *30·10*	10 × 3½ × ·61 *31·15*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·49 *40·75*	12 × 3½ × ·55 *43·55*	12 × 3½ × ·61 *46·40*
47	36½	30·0	9 × 3½ × ·55 *23·00*	*4·0*	10 × 3½ × ·60 *30·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·59 *37·40*	11 × 3½ × ·69 *39·40*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·57 *44·50*	12 × 3½ × ·64 *47·75*
48	37	30·0	*23·20*	*4·0*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·57 *36·60*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·53 *42·60*	12 × 3½ × ·59 *45·45*	12 × 4 × 4 × ·54 *48·60*
49	37½	30·0	*23·40*	*4·0*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·56 *36·20*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·64 *39·40*	12 × 3½ × ·50 *41·20*	12 × 3½ × ·55 *43·55*	12 × 3½ × ·61 *46·40*	12 × 4 × 4 × ·57 *49·80*
50	38	30·0	9 × 3½ × ·57 *23·60*	*4·0*	11 × 3½ × ·48 *33·05*	11 × 3½ × ·52 *34·55*	11 × 3½ × ·59 *37·40*	11 × 3½ × ·62 *38·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·58 *44·95*	12 × 3½ × ·64 *47·75*	12 × 4 × 4 × ·60 *51·00*

BULB ANGLES

Section moduli above are given to nearest ·05

For notes see page 89

TABLE 12

(SEE CONTINUATION)

MAIN FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b		DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET							
					19	20	21	22	23	24	25	26
Feet	Inches	Feet	Per cent		INCHES — Modulus—Inches³							
31	28½	24·8	4·8	BULB ANGLES	10×3½×·56 *29·45*		11×3½×·51 *34·20*	11×3½×·58 *37·00*	11×3½×·65 *39·80*	12×3½×·53 *42·60*	12×3½×·60 *45·90*	12×4×4×·54 *48·60*
32	29	25·6	4·6		10×3½×·61 *31·15*	11×3½×·49 *33·45*	11×3½×·56 *36·20*	11×3½×·64 *39·40*	12×3½×·52 *42·10*	12×3½×·59 *45·45*	12×4×4×·53 *48·20*	12×4×4×·61 *51·40*
33	29½	26·4	4·4		11×3½×·47 *32·70*	11×3½×·54 *35·40*	11×3½×·61 *38·20*	12×3½×·50 *41·20*	12×3½×·55 *43·55*	12×3½×·64 *47·75*	12×4×4×·60 *51·00*	12×4×4×·68 *54·15*
34	30	27·2	4·3		11×3½×·52 *34·55*	11×3½×·58 *37·00*	12×3½×·48 *40·30*	12×3½×·55 *43·55*	12×3½×·62 *46·85*	12×4×4×·58 *50·20*	12×4×4×·66 *53·35*	*57·00*
35	30½	28·0	4·2		11×3½×·56 *36·20*	11×3½×·63 *39·00*	12×3½×·52 *42·10*	12×3½×·59 *45·45*	12×4×4×·55 *49·00*	12×4×4×·64 *52·60*	*56·05*	*60·00*
36	31	28·8	4·1		11×3½×·59 *37·40*	12×3½×·49 *40·75*	12×3½×·56 *44·00*	12×4×4×·51 *47·40*	12×4×4×·60 *51·00*	*54·95*	*58·80*	15×4×4×·45 *62·75*
37	31½	29·4	4·0		11×3½×·65 *39·80*	12×3½×·53 *42·60*	12×3½×·61 *46·40*	12×4×4×·57 *49·80*	12×4×4×·67 *53·75*	*57·40*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*
38	32	30·0	4·0		12×3½×·49 *40·75*	12×3½×·56 *44·00*	12×3½×·64 *47·75*	12×4×4×·61 *51·40*	*55·25*	*59·30*	15×4×4×·46 *63·35*	15×4×4×·54 *68·25*
39	32½	30·0	4·0		12×3½×·52 *42·10*	12×3½×·59 *45·45*	12×4×4×·55 *49·00*	12×4×4×·64 *52·60*	*56·50*	*60·50*	15×4×4×·49 *65·25*	15×4×4×·56 *69·45*
40	33	30·0	4·0		12×3½×·54 *43·05*	12×3½×·61 *46·40*	12×4×4×·58 *50·20*	12×4×4×·68 *54·15*	*57·80*	15×4×4×·44 *62·15*	15×4×4×·50 *65·85*	15×4×4×·57 *70·05*
41	33½	30·0	4·0		12×3½×·57 *44·50*	12×3½×·64 *47·75*	12×4×4×·61 *51·40*	*55·10*	*59·10*	15×4×4×·45 *62·75*	15×4×4×·52 *67·05*	15×4×4×·60 *71·80*
42	34	30·0	4·0		12×3½×·59 *45·45*	12×4×4×·55 *49·00*	12×4×4×·65 *53·00*	*56·40*	*60·30*	15×4×4×·48 *64·60*	15×4×4×·55 *68·85*	15×4×4×·62 *73·00*
43	34½	30·0	4·0		12×3½×·62 *46·85*	12×4×4×·58 *50·20*	12×4×4×·67 *53·75*	*57·70*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·56 *69·45*	15×4×4×·64 *74·20*
44	35	30·0	4·0		12×3½×·64 *47·75*	12×4×4×·61 *51·40*	*55·10*	*59·00*	15×4×4×·45 *62·75*	15×4×4×·52 *67·05*	15×4×4×·59 *71·25*	15×4×4×·66 *75·35*
45	35½	30·0	4·0	CHANNELS	12×4×4×·55 *49·00*	12×4×4×·64 *52·60*	*56·30*	*60·25*	15×4×4×·47 *64·00*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	*76·90*
46	36	30·0	4·0		12×4×4×·58 *50·20*	12×4×4×·67 *53·75*	*57·60*	15×4×4×·43 *61·55*	15×4×4×·50 *65·85*	15×4×4×·56 *69·45*	15×4×4×·63 *73·60*	*78·20*
47	36½	30·0	4·0		12×4×4×·61 *51·40*	*54·90*	*58·80*	15×4×4×·45 *62·75*	15×4×4×·51 *66·45*	15×4×4×·58 *70·65*	15×4×4×·65 *74·80*	*79·45*
48	37	30·0	4·0		12×4×4×·64 *52·60*	*56·10*	*60·05*	15×4×4×·47 *64·00*	15×4×4×·53 *67·65*	15×4×4×·60 *71·80*	*76·05*	17×4×4×·49 *80·85*
49	37½	30·0	4·0		12×4×4×·67 *53·75*	*57·30*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·56 *69·45*	15×4×4×·62 *73·00*	*77·35*	17×4×4×·50 *81·60*
50	38	30·0	4·0		*54·70*	*58·50*	15×4×4×·45 *62·75*	15×4×4×·51 *66·45*	15×4×4×·58 *70·65*	15×4×4×·64 *74·20*	*78·60*	17×4×4×·52 *83·10*

Section moduli above are given to nearest ·05

For notes see page 89

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS OF MAIN FRAMING PER 1 FOOT DIFFERENCE BETWEEN d and d_b*	DEPTH h FROM TOP OF DOUBLE BOTTOM OR SINGLE BOTTOM FLOOR AT SIDE TO TOP OF BEAM AT SIDE OF LOWEST DECK — FEET: 27	28	29	30	31	32	33	34
Feet	Inches	Feet	Per cent	INCHES — *Modulus—Inches³*							
31	28½	24·8	*4·8*	12×4×4×·62 *51·80*	*55·30*	*58·55*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·60 *71·80*	15×4×4×·66 *75·35*
32	29	25·6	*4·6*	*54·95*	*58·45*	15×4×4×·44 *62·15*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*79·60*
33	29½	26·4	*4·4*	*57·95*	15×4×4×·43 *61·55*	15×4×4×·49 *65·25*	15×4×4×·55 *68·85*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	17×4×4×·48 *80·05*	17×4×4×·52 *83·10*
34	30	27·2	*4·3*	*60·90*	15×4×4×·49 *65·25*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*80·45*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*
35	30½	28·0	*4·2*	15×4×4×·47 *64·00*	15×4×4×·54 *68·25*	15×4×4×·61 *72·40*	15×4×4×·68 *76·50*	*80·40*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*
36	31	28·8	*4·1*	15×4×4×·52 *67·05*	15×4×4×·59 *71·25*	15×4×4×·66 *75·35*	*80·00*	17×4×4×·53 *83·85*	17×4×4×·58 *87·55*	17×4×4×·65 *92·75*	17×4×4×·72 *97·80*
37	31½	29·4	*4·0*	15×4×4×·57 *70·05*	15×4×4×·65 *74·80*	*79·00*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*	17×4×4×·71 *97·10*	17×4×4×·78 *102·05*
38	32	30·0	*4·0*	15×4×3×·61 *72·40*	15×4×4×·68 *76·50*	17×4×4×·50 *81·60*	17×4×4×·56 *86·10*	17×4×4×·62 *90·50*	17×4×4×·69 *95·65*	17×4×4×·77 *101·35*	
39	32½	30·0	*4·0*	15×4×4×·63 *73·60*	*78·25*	17×4×4×·52 *83·10*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·71 *97·10*		
40	33	30·0	*4·0*	15×4×4×·65 *74·80*	*79·25*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·66 *93·45*	17×4×4×·72 *97·80*		
41	33½	30·0	*4·0*	15×4×4×·67 *75·95*	*80·50*	17×4×4×·55 *85·35*	17×4×4×·61 *89·75*	17×4×4×·67 *94·20*	17×4×4×·74 *99·25*		
42	34	30·0	*4·0*	15×4×4×·69 *77·10*	17×4×4×·50 *81·60*	17×4×4×·56 *86·10*	17×4×4×·63 *91·25*	17×4×4×·69 *95·65*	17×4×4×·76 *100·65*		
43	34½	30·0	*4·0*	*78·25*	17×4×4×·52 *83·10*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·71 *97·10*	17×4×4×·78 *102·05*		
44	35	30·0	*4·0*	*79·60*	17×4×4×·53 *83·85*	17×4×4×·60 *89·00*	17×4×4×·66 *93·45*	17×4×4×·73 *98·55*			
45	35½	30·0	*4·0*	17×4×4×·49 *80·85*	17×4×4×·55 *85·35*	17×4×4×·62 *90·50*	17×4×4×·68 *94·90*	17×4×4×·74 *99·25*			
46	36	30·0	*4·0*	17×4×4×·51 *82·35*	17×4×4×·57 *86·85*	17×4×4×·63 *91·25*	17×4×4×·70 *96·35*	17×4×4×·76 *100·65*			
47	36½	30·0	*4·0*	17×4×4×·53 *83·85*	17×4×4×·59 *88·30*	17×4×4×·65 *92·75*	17×4×4×·71 *97·10*				
48	37	30·0	*4·0*	17×4×4×·54 *84·60*	17×4×4×·60 *89·00*	17×4×4×·67 *94·20*	17×4×4×·73 *98·55*				
49	37½	30·0	*4·0*	17×4×4×·56 *86·10*	17×4×4×·62 *90·50*	17×4×4×·68 *94·90*					
50	38	30·0	*4·0*	17×4×4×·58 *87·55*	17×4×4×·64 *92·00*	17×4×4×·70 *96·35*					

CHANNELS

Section moduli above are given to nearest ·05

NOTES.—TABLE 12

1. **Correction to modulus of peak framing.**

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by 9 per cent per foot of difference.

2. **Corrections to modulus of main framing.**—The Table modulus is to be corrected, if necessary, as follows :—

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, modulus to be $\frac{\text{increased}}{\text{reduced}}$ by the percentage given in the Table per foot of difference.

FOR TANK SIDE BRACKETS AND BEAM KNEES.

If the height of the tank side brackets above the inner bottom is greater than that derived from Tables 6 and 11 or the depth of the beam knees greater than that required by Table 28 the modulus may be reduced at the rate of 4 per cent per foot of difference.

If the height of the tank side brackets above the inner bottom is less than that derived from Tables 6 and 11 the modulus is to be increased at the rate of 8 per cent per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

3. For framing in deep water ballast tanks, in oil fuel bunkers and in machinery spaces *see* D 19, D 20 and D 22.

4. For increase in boiler rooms and coal bunkers *see* D 614.

5. Particulars of sections and moduli are given in Table 56.

TABLE 13

'TWEEN DECK FRAMING

DEPTH D	FRAME SPACING AMIDSHIPS	BASIC DRAUGHT d_b	*CORRECTION TO MODULUS PER 1 FOOT DIFFERENCE BETWEEN d and d_b*		A	B	C	D	E	F	
Feet	Inches	Feet	Per cent		INCHES *Modulus—Inches³*						
12	21½	9·6	*14·0*	ANGLES		3 × 2½ × ·28 *·90*	3 × 2½ × ·39 *1·30*			3 × 2½ × ·28 *·90*	ANGLES
14	22	11·2	*13·5*			3 × 3 × ·34 *1·15*	3½ × 3 × ·37 *1·60*			3 × 3 × ·30 *1·00*	
16	22½	12·8	*13·0*			3½ × 3 × ·32 *1·40*	4 × 3 × ·36 *2·00*			3 × 3 × ·34 *1·15*	
18	23	14·4	*12·5*			3½ × 3 × ·38 *1·65*	4 × 3 × ·45 *2·45*	5 × 3 × ·40 *3·30*		3 × 3 × ·40 *1·35*	
20	23½	16·0	*12·0*			3½ × 3 × ·46 *2·00*	5 × 3 × ·36 *3·00*	5 × 3 × ·49 *4·05*		3½ × 3 × ·36 *1·55*	
22	24	17·6	*11·4*			4 × 3 × ·43 *2·35*	5 × 3 × ·45 *3·70*	6 × 3 × ·40 *4·75*		4 × 3 × ·32 *1·80*	
24	25	19·2	*10·8*		4 × 3 × ·41 *2·25*	5 × 3 × ·33 *2·80*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*		4 × 3 × ·37 *2·05*	
26	26	20·8	*10·2*		4 × 3½ × ·50 *2·75*	5 × 3½ × ·39 *3·25*	6 × 3½ × ·47 *5·50*	6 × 3½ × ·31 *6·50*	6 × 3½ × ·48 *8·80*	4 × 3½ × ·44 *2·40*	
28	27	22·4	*9·6*		5 × 3½ × ·40 *3·35*	5 × 3½ × ·45 *3·75*	6 × 3½ × ·33 *6·70*	6 × 3½ × ·40 *7·65*	7 × 3½ × ·39 *10·45*	5 × 3½ × ·34 *2·85*	
30	28	24·0	*9·0*		5 × 3½ × ·48 *4·00*	6 × 3½ × ·38 *4·50*	6 × 3½ × ·43 *8·05*	6 × 3½ × ·50 *9·05*	7 × 3½ × ·48 *12·05*	5 × 3½ × ·41 *3·40*	
32	29	25·6	*8·2*		6 × 3½ × ·40 *4·70*	6 × 3½ × ·47 *5·50*	*9·40*	7 × 3½ × ·43 *11·10*	8 × 3½ × ·38 *13·90*	5 × 3½ × ·48 *4·00*	
34	30	27·2	*7·4*		6 × 3½ × ·47 *5·50*	6 × 3½ × ·31 *6·50*	7 × 3½ × ·43 *11·10*	*13·00*	8 × 3½ × ·47 *15·95*	6 × 3½ × ·40 *4·70*	
36	31	28·8	*6·6*	BULB ANGLES	6 × 3½ × ·31 *6·50*	6 × 3½ × ·40 *7·65*	7 × 3½ × ·53 *13·00*	8 × 3½ × ·45 *15·50*	9 × 3½ × ·38 *18·40*	6 × 3½ × ·46 *5·40*	BULB ANGLES
38	32	30·0	*6·0*		6 × 3½ × ·39 *7·55*	6 × 3½ × ·48 *8·80*	8 × 3½ × ·43 *15·00*	8 × 3½ × ·54 *17·60*	9 × 3½ × ·46 *20·50*	6 × 3½ × ·53 *6·15*	
40	33	30·0	*6·0*		6 × 3½ × ·42 *7·95*	*9·35*	8 × 3½ × ·47 *15·95*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	6 × 3½ × ·32 *6·60*	
42	34	30·0	*6·0*		6 × 3½ × ·45 *8·35*	7 × 3½ × ·35 *9·80*	8 × 3½ × ·50 *16·70*	9 × 3½ × ·43 *19·65*	*23·65*	6 × 3½ × ·36 *7·10*	
44	35	30·0	*6·0*		6 × 3½ × ·49 *8·90*	7 × 3½ × ·39 *10·45*	*17·75*	9 × 3½ × ·48 *21·05*	10 × 3½ × ·43 *25·10*	6 × 3½ × ·40 *7·65*	
46	36	30·0	*6·0*		*9·35*	7 × 3½ × ·42 *10·95*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·48 *26·75*	6 × 3½ × ·44 *8·20*	
48	37	30·0	*6·0*		7 × 3½ × ·35 *9·80*	7 × 3½ × ·45 *11·50*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·53 *28·45*	6 × 3½ × ·47 *8·65*	
50	38	30·0	*6·0*		7 × 3½ × ·38 *10·25*	7 × 3½ × ·47 *11·85*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·58 *23·85*	10 × 3½ × ·57 *29·80*	6 × 3½ × ·51 *9·20*	

Section moduli above are given to nearest ·05

For notes see page 91

TABLE 13

'TWEEN DECK FRAMING

NOTES.—TABLE 13

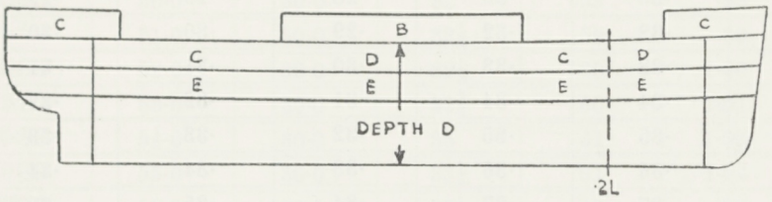


Diagram I

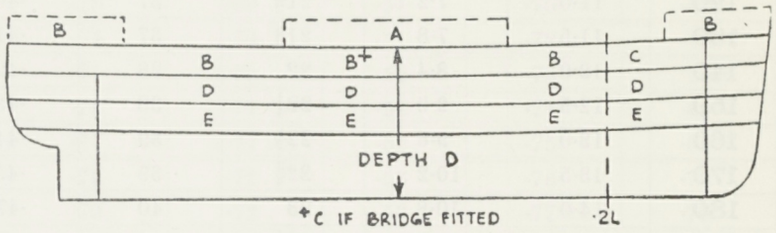


Diagram II

1. **Scantlings.**—The scantlings of the 'tween deck frames are given in cols. A to F. The positions to which each column between A and E applies are shown in the diagrams ; for col. F *see* note 3. The scantlings given in the Table apply to frames fitted at every frame.

Diagram I is to be used when the ratio of draught d to depth D exceeds ·75.

Diagram II is to be used when the ratio of draught d to depth D is—

less than ·68 when D exceeds 22 feet

„ „ ·60 „ D is 18 feet ;

intermediate values to be obtained by interpolation.

When the value of the ratio d/D falls between the limits defined above the scantlings of the framing are to be determined by interpolation.

2. **Corrections to modulus of framing.**

FOR DRAUGHT

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, modulus to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by the percentage given in the Table per foot of difference.

FOR FRAME SPACING.

If the spacing amidships differs from that given in the Table, modulus to be modified in direct proportion. (*See* also D 604 to D 607.)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height at side is greater than 8 feet 6 inches, modulus to be increased in direct proportion.

3. If the framing in a 'tween deck consists of alternate frames extended from below with intermediate frames the mean modulus per frame space is to be as required for uniform framing, but the modulus of the intermediate frames is not to be less than that given in col. F. If frames are fitted two spaces apart (*see* D 609) the mean modulus per frame space is to be maintained.

4. Where several tiers of superstructures are fitted the scantlings and arrangements of the framing will be specially considered.

5. For increase in 'tween deck bunkers *see* D 614.

6. Particulars of sections and moduli are given in Table 56.

TABLE 14

(SEE CONTINUATION)

SHELL PLATING

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS	WIDTH OF FLAT PLATE KEEL	THICKNESS OF FLAT PLATE KEEL	THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS		THICKNESS OF SIDE AND BOTTOM PLATING FOR ·05L FROM ENDS	MINIMUM THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS	
						FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE		FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE
1	2	3	4	5	6	7	8	9	10	11
Feet	Feet	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	10·0	6·0	21	36	·38	·26	·26	·25	·26	·26
110	10·5	6·6	21¼	36	·39	·27	·27	·26	·27	·27
120	11·0	7·2	21½	37	·40	·29	·29	·27	·28	·28
130	11·5	7·8	21¾	37	·41	·30	·30	·28	·29	·29
140	12·0	8·4	22	38	·42	·32	·32	·29	·30	·30
150	12·5	9·0	22¼	38	·43	·33	·33	·30	·31	·31
160	13·0	9·6	22½	39	·44	·34	·34	·31	·32	·32
170	13·5	10·2	22¾	39	·45	·35	·35	·32	·33	·33
180	14·0	10·8	23	40	·47	·36	·36	·33	·34	·34
190	15·0	11·4	23¼	40	·48	·37	·37	·34	·35	·35
200	16·0	12·0	23½	41	·50	·38	·38	·34	·36	·36
210	17·0	12·6	23¾	41	·51	·39	·39	·35	·37	·37
220	18·0	13·2	24	42	·52	·40	·40	·35	·38	·38
230	19·0	13·8	24¼	42	·53	·41	·41	·36	·39	·39
240	20·0	14·4	24½	43	·55	·42	·42	·37	·40	·40
250	21·0	15·0	24¾	43	·56	·43	·43	·37	·41	·41
260	22·0	15·6	25	44	·57	·44	·44	·38	·42	·42
270	23·0	16·2	25¼	44	·58	·45	·45	·38	·42	·42
280	24·0	16·8	25½	45	·60	·46	·46	·39	·43	·43
290	25·0	17·4	25¾	45	·61	·47	·47	·39	·43	·43
300	26·0	18·0	26	46	·63	·48	·48	·40	·44	·44
310	27·0	18·6	26¼	46	·64	·49	·49	·40	·44	·44
320	28·0	19·2	26½	47	·66	·50	·50	·41	·45	·45
330	29·0	19·8	26¾	47	·67	·51	·51	·41	·46	·46
340	30·0	20·4	27	48	·69	·52	·52	·42	·47	·47
350	31·0	21·0	27¼	48	·70	·53	·53	·42	·48	·48
360	32·0	21·6	27½	49	·72	·54	·54	·43	·49	·49
370	33·0	22·2	27¾	49	·74	·55	·55	·43	·50	·50
380	34·0	22·8	28	50	·76	·56	·56	·44	·51	·51
390	35·0	23·4	28¼	50	·77	·57	·56	·44	·52	·52
400	36·0	24·0	28½	51	·79	·58	·57	·45	·53	·53
410	37·0	24·6	28¾	51	·80	·59	·58	·45	·54	·54
420	38·0	25·2	29	52	·82	·60	·59	·46	·55	·55
430	39·0	25·8	29¼	52	·83	·61	·60	·46	·56	·56
440	40·0	26·4	29½	53	·85	·63	·61	·47	·57	·57
450	41·0	27·0	29¾	53	·86	·64	·62	·47	·58	·58
460	42·0	27·6	30	54	·88	·66	·63	·48	·59	·59
470	43·0	28·2	30¼	54	·89	·67	·64	·48	·60	·60
480	44·0	28·8	30½	55	·91	·68	·65	·49	·62	·62
490	45·0	29·4	30¾	55	·92	·69	·66	·49	·64	·63
500	46·0	30·0	31	56	·94	·70	·67	·50	·66	·65

For notes see page 93

LENGTH L	BASIC DEPTH D_b	BASIC DRAUGHT d_b	FRAME SPACING AMIDSHIPS	WIDTH OF FLAT PLATE KEEL	THICKNESS OF FLAT PLATE KEEL	THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS		THICKNESS OF SIDE AND BOTTOM PLATING FOR ·05L FROM ENDS	MINIMUM THICKNESS OF SHELL PLATING FOR ·4L AMIDSHIPS	
						FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE		FROM KEEL TO UPPER TURN OF BILGE	FROM UPPER TURN OF BILGE TO SHEERSTRAKE
1	2	3	4	5	6	7	8	9	10	11
Feet	Feet	Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
510	47·0	30·0	31¼	57	·95	·71	·67	·50	·67	·65
520	48·0	30·0	31½	57	·96	·72	·68	·50	·69	·66
530	49·0	30·0	31¾	58	·97	·73	·69	·51	·70	·67
540	50·0	30·0	32	59	·98	·74	·70	·51	·72	·68
550	51·0	30·0	32¼	59	·99	·75	·70	·52	·73	·68
560	52·0	30·0	32½	60	1·00	·76	·71	·52	·74	·69
570	53·0	30·0	32¾	60	1·01	·77	·71	·52	·75	·69
580	54·0	30·0	33	61	1·03	·78	·72	·53	·76	·70
590	55·0	30·0	33¼	61	1·04	·79	·72	·53	·77	·70
600	56·0	30·0	33½	62	1·06	·80	·73	·54	·78	·71
610	57·0	30·0	33¾	63	1·07	·81	·73	·54	·79	·71
620	58·0	30·0	34	63	1·08	·82	·74	·54	·80	·72
630	59·0	30·0	34¼	64	1·09	·83	·75	·55	·81	·73
640	60·0	30·0	34½	65	1·11	·84	·76	·55	·82	·74
650	61·0	30·0	34¾	65	1·12	·85	·76	·55	·83	·74

NOTES.—TABLE 14

1. **Keel.**—The width and thickness of the keel plate (cols. 5 and 6) are to be maintained throughout.

2. **Garboard strake**—If a bar keel is fitted, the thickness of the garboard strake is to be 85 per cent of that required for keel plate (col. 6); this thickness is to be maintained for ·4L amidships and may be 85 per cent of the amidships thickness for ·05L at the ends, but in way of strengthening of bottom forward is not to be less than required for bottom plating.

3. **Bottom and side plating.**—The Table thickness of bottom and side plating for ·4L amidships (cols. 7 and 8) is to be corrected, if necessary, as follows :—

FOR DEPTH.

If D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than D_b, thickness to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ by 0·7 per cent per foot of difference.

FOR DRAUGHT.

If d is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than d_b, thickness to be $\begin{matrix}\text{increased}\\\text{reduced}\end{matrix}$ by 1·5 per cent per foot of difference.

If both these corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth*+1·22%; *correction for draught*—3·37%; *total factor* 1·012×·966=·978.)

The thickness for ·05 L at ends given in col. 9 are not subject to the above corrections.

4. **Effective superstructure.**—If an effective superstructure as defined in D 206 is fitted the shell plating may be modified as stated in D 703.

5. **Frame spacing.**—If the spacing amidships differs from the Table spacing (col. 4) the thickness of bottom and side plating is to be modified at the rate of ·01 inch for every inch of difference, but where the spacing amidships exceeds the Table spacing by 3 inches or more the increase required will be specially considered.

Where the bottom is framed longitudinally the thickness of the bottom shell plating is to be modified at the same rate for every inch of difference of spacing from that given in Table 10.

6. **Minimum thickness**—The thickness of the bottom and side plating for ·4L amidships, after correction as required by notes 3 and 5, is not to be less than that given in cols. 10 and 11, corrected as required by note 5 only.

7. **Local strengthening.**—Plates connected to the sternframe or propeller brackets are to have the thickness given in col. 8 without corrections and those which require to be furnaced are to be of that thickness when finished.

For strengthening of bottom forward *see* D 802.

For strengthening at openings in shell *see* D 705 to D 706.

For strengthening at ends of superstructures *see* D 1206 and D 1305 to D 1308.

For strengthening for navigation in ice *see* D 1003, D 1011 and D 1019.

TABLE 15

BEAMS IN PEAKS BELOW LOWEST DECK

BREADTH B	BEAM	KNEE	RIVETS	
Feet	Inches	Inches	Number	Inches
22	BULB ANGLES 5 ×3 ×·28	15 ×·30	4	$\frac{3}{4}$
26	BULB ANGLES 5 ×3 ×·32	15 ×·32	4	$\frac{3}{4}$
30	BULB ANGLES $5\frac{1}{2}$ ×3 ×·34	$16\frac{1}{2}$ ×·34	5	$\frac{3}{4}$
34	BULB ANGLES 6 ×3 ×·36	18 ×·34	6	$\frac{3}{4}$
38	CHANNELS 6 ×3 ×3 ×·32	20 ×·36	6	$\frac{3}{4}$
42	CHANNELS 6 ×3 ×3 ×·42	22 ×·38	6	$\frac{7}{8}$
46	CHANNELS 7 ×3 ×3 ×·40	24 ×·38	6	$\frac{7}{8}$
50	CHANNELS 8 ×3 ×3 ×·44	26 ×·40	6	$\frac{7}{8}$
54	CHANNELS 8 ×$3\frac{1}{2}$ ×$3\frac{1}{2}$ ×·40	28 ×·42	7	$\frac{7}{8}$

NOTE.—TABLE 15

Where B is greater than 54 feet the scantlings of the beams are to be specially considered in relation to the size and form of the ship.

TABLE 16

STRINGERS IN PANTING REGION

LENGTH L	FORWARD OF COLLISION BULKHEAD		ABAFT COLLISION BULKHEAD	
	STRINGER PLATE		THICKNESS OF INTERCOSTAL PLATE	FACE ANGLE
	WIDTH	THICKNESS		
Feet	Inches	Inches	Inches	Inches
100	22	·26	·28	ANGLES $2\frac{1}{2}$ ×$2\frac{1}{2}$ ×·30
200	25	·29	·31	ANGLES 3 ×3 ×·36
300	28	·32	·35	ANGLES $4\frac{1}{2}$ ×3 ×·40
400	32	·35	·39	ANGLES 6 ×$3\frac{1}{2}$ ×·42
500	36	·38	·42	BULB ANGLES 7 ×$3\frac{1}{2}$ ×·42
600	40	·41	·46	BULB ANGLES 8 ×$3\frac{1}{2}$ ×·48

ICE STRENGTHENING—CLASS 3
INTERMEDIATE FRAMES

LENGTH L	INTERMEDIATE FRAMES	
	FORWARD OF COLLISION BULKHEAD	ABAFT COLLISION BULKHEAD
Feet	INCHES *Modulus—Inches³*	
100	ANGLES: 3 × 3 × ·28 *·92*	ANGLES: 4 × 3 × ·36 *2·00*
150	3 × 3 × ·36 *1·20*	5 × 3 × ·32 *2·70*
200	3½ × 3 × ·40 *1·75*	5 × 3 × ·42 *3·50*
250	4 × 3 × ·45 *2·45*	BULB ANGLES: 5 × 3 × ·36 *4·75*
300	5 × 3 × ·42 *3·50*	5½ × 3 × ·40 *6·25*
350	6 × 3 × ·40 *4·75*	6 × 3 × ·43 *8·05*
400	6 × 3½ × ·53 *6·20*	7 × 3½ × ·37 *10·15*
450	BULB ANGLES: 6 × 3½ × ·40 *7·65*	7 × 3½ × ·50 *12·45*
500	6 × 3½ × ·51 *9·20*	8 × 3½ × ·42 *14·80*

TABLE 18

(SEE CONTINUATION)

TOPSIDE SCANTLINGS

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK	THICKNESS OF SHEERSTRAKE FOR ·4L AMIDSHIPS	SECTIONAL AREAS OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17). WHERE ONE DECK FITTED		
							SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN* D *and* D_b	d *and* d_b
1	2	3	4	5	6	7	8	9	10
Feet	Feet	Feet	Feet	Inches	Inches	Inches	Square inches	Per cent	Per cent
100	25	10	6·0	21	42	·28	9	*18·40*	*21·00*
110	26	10·5	6·6	21¼	42	·29	10	*15·90*	*20·10*
120	27	11	7·2	21½	43	·30	12	*14·30*	*19·20*
130	28	11·5	7·8	21¾	44	·32	13	*13·15*	*18·40*
140	29	12	8·4	22	45	·34	15	*12·25*	*17·60*
150	30	12·5	9·0	22¼	45	·36	18	*11·45*	*16·70*
160	31	13	9·6	22½	46	·37	21	*10·80*	*15·90*
170	32	13·5	10·2	22¾	46	·38	24	*10·20*	*15·10*
180	33	14	10·8	23	47	·40	27	*9·70*	*14·30*
190	34	15	11·4	23¼	48	·41	29	*9·25*	*13·55*
200	35	16	12·0	23½	49	·43	32	*8·80*	*12·80*
210	36	17	12·6	23¾	50	·44	35	*8·40*	*12·10*
220	37	18	13·2	24	51	·45	38	*8·00*	*11·40*
230	38	19	13·8	24¼	51	·46	41	*7·70*	*10·75*
240	39	20	14·4	24½	52	·47	45	*7·40*	*10·10*
250	40	21	15·0	24¾	52	·48	49	*7·20*	*9·50*
260	41	22	15·6	25	53	·50	54	*6·95*	*8·95*
270	42	23	16·2	25¼	53	·51	59	*6·70*	*8·45*
280	43	24	16·8	25½	54	·53	65	*6·50*	*7·90*
290	44	25	17·4	25¾	54	·54	71	*6·35*	*7·50*
300	45	26	18·0	26	55	·55	78	*6·15*	*7·10*
310	46	27	18·6	26¼	55	·56	84	*6·00*	*6·70*
320	47	28	19·2	26½	56	·57	91	*5·85*	*6·30*
330	48	29	19·8	26¾	56	·58	99	*5·70*	*5·95*
340	49	30	20·4	27	57	·59	106	*5·55*	*5·60*
350	50	31	21·0	27¼	57	·60	114	*5·40*	*5·30*
360	51	32	21·6	27½	58	·61	123	*5·25*	*5·05*
370	52	33	22·2	27¾	58	·63	131	*5·10*	*4·80*
380	53	34	22·8	28	59	·64	140	*4·95*	*4·60*
390	54	35	23·4	28¼	59	·65	150	*4·80*	*4·45*
400	55	36	24·0	28½	60	·67	160	*4·70*	*4·30*
410	56	37	24·6	28¾	60	·68	170	*4·55*	*4·20*
420	57	38	25·2	29	61	·70	180	*4·40*	*4·15*
430	58	39	25·8	29¼	61	·71	191	*4·30*	*4·10*
440	59	40	26·4	29½	62	·73	201	*4·20*	*4·05*
450	60	41	27·0	29¾	62	·74	213	*4·10*	*4·00*
460	61	42	27·6	30	63	·75			
470	62	43	28·2	30¼	63	·76			
480	63	44	28·8	30½	64	·78			
490	64	45	29·4	30¾	64	·79			
500	65	46	30·0	31	65	·80			

For notes see pages 98, 99 & 100

TOPSIDE SCANTLINGS

TABLE 18

(SEE CONTINUATION)

SECTIONAL AREA OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM							MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·4L AMIDSHIPS		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·1L FROM ENDS		LENGTH L
WHERE TWO DECKS FITTED			WHERE THREE DECKS FITTED			ALL STRENGTH DECKS					
SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:*		SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:*		*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN*	OUTSIDE LINE OF OPENINGS	INSIDE LINE OF OPENINGS	STRINGER	PLATING	
	D *and* D_b	d *and* d_b		D *and* D_b	d *and* d_b	B *and* B_b					
11	12	13	14	15	16	17	18	19	20	21	22
Square inches	Per cent	Per cent	Square inches	Per cent	Per cent	Per cent	Inches	Inches	Inches	Inches	Feet
						4·0	·26	·26	·26	·26	100
						4·0	·26	·26	·26	·26	110
						4·0	·27	·26	·27	·26	120
						4·0	·27	·27	·27	·26	130
						4·0	·28	·27	·28	·26	140
						4·0	·28	·27	·28	·26	150
						4·0	·29	·28	·29	·27	160
						4·0	·30	·28	·29	·27	170
25	*13·65*	*11·20*				*4·0*	·31	·28	·30	·27	180
27	*13·10*	*11·05*				*4·0*	·31	·28	·30	·27	190
30	*12·50*	*10·90*				*4·0*	·32	·29	·31	·28	200
32	*12·00*	*10·70*				*4·0*	·32	·29	·31	·28	210
34	*11·50*	*10·50*				*4·0*	·33	·29	·32	·28	220
37	*11·00*	*10·35*				*4·0*	·33	·29	·32	·28	230
40	*10·55*	*10·15*				*4·0*	·34	·30	·33	·29	240
43	*10·05*	*9·95*				*4·0*	·34	·30	·33	·29	250
47	*9·60*	*9·70*				*4·0*	·35	·31	·34	·29	260
51	*9·25*	*9·45*				*4·0*	·35	·31	·34	·29	270
55	*8·95*	*9·20*				*4·0*	·36	·32	·35	·30	280
59	*8·70*	*8·85*				*4·0*	·36	·32	·35	·30	290
64	*8·45*	*8·50*				*4·0*	·37	·33	·36	·30	300
69	*8·20*	*8·05*				*3·9*	·37	·33	·36	·30	310
75	*8·00*	*7·60*				*3·8*	·38	·34	·37	·31	320
80	*7·80*	*7·15*				*3·7*	·38	·34	·37	·31	330
85	*7·65*	*6·75*	81	*9·50*	*7·05*	*3·6*	·39	·34	·38	·31	340
91	*7·50*	*6·40*	87	*9·10*	*6·70*	*3·5*	·39	·34	·38	·31	350
98	*7·30*	*6·05*	94	*8·70*	*6·35*	*3·4*	·40	·35	·39	·32	360
105	*7·10*	*5·70*	100	*8·35*	*6·05*	*3·3*	·40	·35	·39	·32	370
113	*6·90*	*5·45*	107	*8·05*	*5·75*	*3·2*	·41	·35	·39	·32	380
120	*6·75*	*5·20*	113	*7·80*	*5·50*	*3·1*	·41	·35	·39	·32	390
128	*6·60*	*5·00*	121	*7·55*	*5·30*	*3·0*	·42	·36	·40	·33	400
135	*6·40*	*4·80*	129	*7·35*	*5·10*	*2·9*	·43	·36	·40	·33	410
144	*6·20*	*4·65*	137	*7·20*	*4·95*	*2·8*	·44	·36	·40	·33	420
152	*6·00*	*4·50*	146	*7·05*	*4·80*	*2·7*	·44	·36	·40	·33	430
161	*5·85*	*4·40*	153	*6·95*	*4·70*	*2·6*	·45	·37	·41	·34	440
170	*5·70*	*4·30*	161	*6·80*	*4·55*	*2·5*	·45	·37	·41	·34	450
179	*5·50*	*4·20*	169	*6·70*	*4·45*	*2·4*	·46	·37	·41	·34	460
189	*5·30*	*4·15*	177	*6·60*	*4·40*	*2·3*	·46	·37	·41	·34	470
199	*5·10*	*4·10*	185	*6·50*	*4·30*	*2·2*	·47	·38	·42	·34	480
209	*4·95*	*4·05*	193	*6·40*	*4·25*	*2·1*	·47	·38	·42	·34	490
219	*4·80*	*4·00*	201	*6·30*	*4·20*	*2·0*	·48	·38	·42	·35	500

For notes see pages 98, 99 & 100

TABLE 18

TOPSIDE SCANTLINGS

(SEE CONTINUATION)

LENGTH L	BASIC BREADTH B_b	BASIC DEPTH D_b	BASIC DRAUGHT d_b	BEAM SPACING AMIDSHIPS	WIDTH OF SHEERSTRAKE AND STRINGER PLATE OF PLATED DECK	THICKNESS OF SHEERSTRAKE FOR ·4L AMIDSHIPS	SECTIONAL AREAS OF STRENGTH DECK FOR ·4 L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM. (Col.17) WHERE ONE DECK FITTED		
							SECTIONAL AREA	*CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:*	
								D *and* D_b	d *and* d_b
1	2	3	4	5	6	7	8	9	10
Feet	Feet	Feet	Feet	Inches	Inches	Inches	Square inches	Per cent	Per cent
510	66	47	30·0	$31\frac{1}{4}$	65	·81			
520	67	48	30·0	$31\frac{1}{2}$	66	·82			
530	68	49	30·0	$31\frac{3}{4}$	66	·82			
540	69	50	30·0	32	67	·83			
550	70	51	30·0	$32\frac{1}{4}$	67	·84			
560	71	52	30·0	$32\frac{1}{2}$	68	·85			
570	72	53	30·0	$32\frac{3}{4}$	68	·85			
580	73	54	30·0	33	69	·86			
590	74	55	30·0	$33\frac{1}{4}$	69	·87			
600	75	56	30·0	$33\frac{1}{2}$	70	·87			
610	76	57	30·0	$33\frac{3}{4}$	71	·88			
620	77	58	30·0	34	72	·89			
630	78	59	30·0	$34\frac{1}{4}$	73	·89			
640	79	60	30·0	$34\frac{1}{2}$	74	·90			
650	80	61	30·0	$34\frac{3}{4}$	75	·90			

NOTES.—TABLE 18

1. Sheerstrake.—(*a*) The Table thickness of the sheerstrake (col. 7) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, thickness to be $\frac{\text{reduced}}{\text{increased}}$ by 4 per cent per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, thickness to be $\frac{\text{increased}}{\text{reduced}}$ by 4 per cent per foot of difference.

If both corrections are required the factors derived from each correction are to be multiplied together and not applied separately to the Table thickness. (*Example: Correction for depth* +7·32%; *correction for draught* −10·16%; *total factor*=1·073×·898=·964.)

(*b*) The thickness of sheerstrake is not to be corrected for frame spacing, but is not to be less, for ·4L amidships, than the side plating.

The thickness of sheerstrake at ends is to be the same as that of the side plating except in ships in which the draught does not exceed ·7D (D being measured to the uppermost continuous deck) when the end thickness may be as required for a poop or forecastle aft or forward respectively.

2. Plated strength deck.—(*a*) The area given in cols. 8, 11 and 14 is the sectional area of deck plating including stringer plate and stringer angle for one side of the ship abreast openings. If riveted overlap seams are fitted, they may be included in determining the required deck thickness.

(*b*) The Table area (cols. 8, 11 and 14) is to be corrected, if necessary, as follows:—

FOR DEPTH.

If D is $\frac{\text{greater}}{\text{less}}$ than D_b, area to be $\frac{\text{reduced}}{\text{increased}}$ by the given percentage (cols. 9, 12 and 15) per foot of difference.

FOR DRAUGHT.

If d is $\frac{\text{greater}}{\text{less}}$ than d_b, area to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (cols. 10, 13 and 16) per foot of difference.

FOR BREADTH.

If B is $\frac{\text{greater}}{\text{less}}$ than B_b, area to be $\frac{\text{increased}}{\text{reduced}}$ by the given percentage (col. 17) per foot of difference.

If more than one of the above corrections is required the factors derived from the individual corrections are to be multiplied together and not applied separately to the Table area. (*Example* : *Correction for depth* − 13·81% ; *correction for draught* + 3·92% ; *correction for breadth* + 9·12% ; *total factor* = ·862 × 1·039 × 1·091 = ·978.)

SECTIONAL AREAS OF STRENGTH DECK FOR ·4L AMIDSHIPS AND CORRECTIONS FOR DEPTH, DRAUGHT AND BEAM							MINIMUM THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·4L AMIDSHIPS		THICKNESS OF UNSHEATHED PLATING OF STRENGTH DECK FOR ·1L FROM ENDS		LENGTH L
WHERE TWO DECKS FITTED			WHERE THREE DECKS FITTED			ALL STRENGTH DECKS					
SECTIONAL AREA	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:		SECTIONAL AREA	CORRECTION PER 1 FOOT DIFFERENCE BETWEEN:		CORRECTION PER 1 FOOT DIFFERENCE BETWEEN	OUTSIDE LINE OF OPENINGS	INSIDE LINE OF OPENINGS	STRINGER	PLATING	
	D *and* D_b	d *and* d_b		D *and* D_b	d *and* d_b	B *and* B_b					
11	12	13	14	15	16	17	18	19	20	21	22
Square inches	Per cent	Per cent	Square inches	Per cent	Per cent	Per cent	Inches	Inches	Inches	Inches	Feet
227	*4·55*	*4·00*	209	*5·95*	*4·20*	*2·0*	·48	·38	·42	·35	**510**
237	*4·30*	*4·00*	217	*5·55*	*4·20*	*2·0*	·49	·39	·43	·35	**520**
246	*4·05*	*4·00*	225	*5·20*	*4·20*	*2·0*	·49	·39	·43	·35	**530**
256	*3·80*	*4·00*	233	*4·90*	*4·20*	*2·0*	·50	·39	·43	·35	**540**
265	*3·60*	*4·00*	241	*4·60*	*4·20*	*2·0*	·50	·39	·43	·35	**550**
273	*3·45*	*4·00*	249	*4·35*	*4·20*	*2·0*	·50	·40	·44	·36	**560**
			257	*4·10*	*4·20*	*2·0*	·50	·40	·44	·36	**570**
			266	*3·85*	*4·20*	*2·0*	·50	·40	·44	·36	**580**
			274	*3·65*	*4·20*	*2·0*	·50	·40	·44	·36	**590**
			282	*3·50*	*4·20*	*2·0*	·50	·41	·45	·36	**600**
			290	*3·35*	*4·20*	*2·0*	·50	·41	·45	·36	**610**
			299	*3·25*	*4·20*	*2·0*	·50	·41	·45	·37	**620**
			307	*3·15*	*4·20*	*2·0*	·50	·41	·45	·37	**630**
			315	*3·10*	*4·20*	*2·0*	·50	·42	·46	·37	**640**
			325	*3·00*	*4·20*	*2·0*	·50	·42	·46	·37	**650**

NOTES.—TABLE 18 *(continued)*

The deck area obtained after the above corrections is the minimum area. This area may require to be increased for special characteristics in design as required in note 2(*c*). (For longitudinal framing *see* note 3.)

(*c*) Where there is no effective superstructure (*see* D 206) on the strength deck, the sectional area of the strength deck plating as computed from notes 2(*a*) and 2(*b*) is to be increased by multiplying the area by the factor

$$F = \frac{L \times C_b}{100 \times d} \times f,$$ if this factor is greater than unity.

Where C_b = moulded block coefficient at load draught.

L = length between perpendiculars, in feet.

d = summer draught, in feet, measured from top of keel.

f is to be determined in the following manner:—

Where l = length, in feet, of machinery space between main bulkheads including mean length of adjacent cross bunkers, if any.

x = distance, in feet, of centre of the length 'l' from midships.

m = weight of machinery, in tons, excluding propellers and shafting, but including all auxiliary machinery in machinery space.

W = load displacement, in tons.

V = sea speed, in knots.

s = product of length, mean breadth and height, in feet, of cargo space in forecastle, poop or after 'tween decks as defined below.

z = distance, in feet, of centre of length of above cargo space from amidships.

Then f is the algebraic summation of the following terms "a" and "b" in all cases and "c" and "d_t" where applicable, multiplied by $\frac{1 + \frac{V^2}{L}}{1{\cdot}5}$

"a" "b" "c" and "d_t" are obtained as follows:—

"a" is taken from Table 18A for the appropriate values of l/L and x/L.

"b" is calculated from Table 18B to give effect to any departure from a standard value of m/W = ·06, and may be positive or negative.

"c". If a forecastle and/or poop is fitted on the continuous strength deck for the carriage of cargo, or if cargo is carried in the upper 'tween decks

NOTES.—TABLE 18 (*concluded*).

abaft ·05L forward of the after perpendicular, a further term "c" is to be calculated and added as follows:—

For a forecastle, poop and/or after 'tween deck

$$\frac{3{\cdot}8\ s\ (z\ -\ {\cdot}25\ l\ -\ {\cdot}2L)}{WL}$$

(NOTE.—In calculating "s" for an after 'tween deck the length of the space need only be measured abaft ·05L forward of the after perpendicular.)

"d_t". If owners desire provision to be made in the longitudinal scantlings for loaded voyages with one or more midship deep tanks empty an additional term "d_t", calculated for each deep tank as follows, is to be added to "a", "b" and "c" when calculating the value of "f".

$$d_t = \frac{150\ C\ ({\cdot}25\ l\ +\ {\cdot}2L - y)}{WL}$$

Where C = capacity of deep tank, in tons, of salt water,

y = distance, in feet, of centre of length of deep tank from amidships.

This correction is applicable to ships having machinery amidships and for midship deep tanks only; it is not to be applied to tanks at ends where the value of "d_t" is negative.

(*d*) Where a long continuous deckhouse extending over at least ·15L amidships and not less in breadth than ·8B is fitted, the increased deck area required by note 2(*c*) may extend from a distance of ·04L inside the deckhouse at each end to ·2L from midships. Within the remainder of the deckhouse the deck area is to be that required by note 2(*b*). (For Deckhouses *see* D 1208 to D 1211.)

(*e*) The requirements of notes 2 (*c*) and 2 (*d*) may be modified as necessary to take account of any special features in the design arrangements not covered by the formula.

3. Longitudinal framing.—Where the strength deck is framed longitudinally, the sectional area of deck plating including stringer plate and stringer angle may be 10 per cent less than that obtained by note 2. The associated basic total area of longitudinals is to be 20 per cent of the sectional area so obtained.

If the total area of longitudinals fitted exceeds the basic area, 75 per cent of the excess may be deducted from the area of deck plating, but the thickness must not be less than required by column 18. If the total area of longitudinals fitted is less than the basic area, the whole deficiency in area is to be added to the area of deck plating.

4. 'Tween deck height.—If the midship height of the 'tween decks below the strength deck exceeds 8 feet 6 inches at side, the area of the strength deck, corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) is to be increased at the rate of 5 per cent of the Rule area of the second deck in two-deck ships, and 7 per cent of the Rule area of the second deck in three-deck ships, per foot increase in 'tween deck height. If the second 'tween deck height exceeds 8 feet 6 inches, a further increase may be required.

If the midship height of the 'tween decks below the strength deck is less than 8 feet 6 inches at side, the area of the strength deck corrected as required by notes 2 (*b*), 2 (*c*) and 2 (*d*) may be reduced at the rate of 5 per cent of the Rule area of the second deck per foot reduction in 'tween deck height.

5. Beam spacing.—If the spacing of beams amidships differs from that given in col. 5, or with longitudinal framing from that given in Table 26, the minimum thickness of deck plating outside line of openings (col. 18) is to be modified at the rate of ·01 inch for every 2 inches of difference, and the minimum thickness of deck plating inside line of openings (col. 19) at the rate of ·01 inch for each complete 4 inches.

6. Stringer plates.—The thickness of strength deck stringer plates amidships is not to be less than 85 per cent of the thickness of sheerstrake, corrected as required by note 1, nor less than ·04 inch greater than that given in col. 18.

The width of stringer plates for ·1L at ends is not to be less than 60 per cent of the width amidships (col. 6).

7. Stringer angles.—Scantlings are to be in accordance with Table 19.

8. Sheathed decks.—Where plated decks are sheathed with wood or approved composition the thickness given in col. 18 may be reduced by 15 per cent in ships over 170 feet in length and by 10 per cent in smaller ships, and that given in cols. 19, 20 and 21 may be reduced by 10 per cent for all ships.

9. Effective superstructures.—If an effective superstructure as defined in D 206 is fitted amidships the scantlings of the upper and second decks in way of the superstructure are to be those required for the second and third decks respectively.

10. Strength deck with stringers and tie plates.—Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for ·4L amidships, required for a plated deck.

The width of stringer plates for ·4L amidships is not to be less than 22 inches and 54 inches for lengths of 100 feet and 260 feet respectively with intermediate values in proportion. The width for ·1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 12 inches and 20 inches for lengths of 100 feet and 260 feet respectively with intermediate values in proportion.

The thickness of the stringer and tie plates is not to be less than given in col. 20, but stringer plates for ·4L amidships are not to be less than 85 per cent of the Rule thickness of sheerstrake.

11. Local strengthening.—For strengthening at the ends of superstructures *see* D 1206 and D 1305 to D 1308.

For strengthening at openings *see* D 1108.

For strengthening in ships having concentrated loading amidships *see* D 1107.

TABLE 18A

Term "a" of Basic Deck Factor f (Note 2 (c)) for $m/W = \cdot 06$

l/L	x/L					
	·02	·04	·06	·08	·10	·12
·11	5·85	5·65	5·34	4·84	4·11	3·06
·12	6·42	6·22	5·91	5·40	4·69	3·78
·13	6·96	6·75	6·42	5·94	5·34	4·50
·14	7·46	7·26	6·96	6·49	5·91	5·18
·15	7·92	7·74	7·45	6·99	6·48	5·83
·16	8·38	8·16	7·90	7·48	7·00	6·48
·17	8·80	8·59	8·32	7·95	7·54	7·06
·18	9·18	8·98	8·71	8·40	8·04	7·63
·19	9·54	9·35	9·08	8·79	8·47	8·12
·20	9·85	9·66	9·45	9·17	8·88	8·56
·21	10·14	9·95	9·74	9·48	9·20	8·93

TABLE 18B

Term "b" of Basic Deck Factor f (Note 2(c))

Value per ·01 Difference in m/W from ·06

x/L	CORRECTION	x/L	CORRECTION
·0	·526	·06	·440
·01	·522	·07	·412
·02	·514	·08	·380
·03	·502	·09	·345
·04	·486	·10	·312
·05	·464	·11	·277
		·12	·242

The term "b" is $\frac{\text{positive}}{\text{negative}}$ when m/W is $\frac{\text{less}}{\text{greater}}$ than ·06.

TABLE 19

STRINGER ANGLES ON STRENGTH DECKS

THICKNESS OF SHEERSTRAKE OR STRINGER PLATE WHICHEVER IS THE GREATER		DIAMETER OF RIVET AS REQUIRED BY TABLE 52	SIZES OF FLANGES *	SPACING OF RIVETS
Above	not exceeding	Inches	Inches	Diameters
Inches				
—	·36	$\frac{5}{8}$	3 × 3	$4\frac{1}{2}$
·36	·50	$\frac{3}{4}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$
·50	·56	$\frac{7}{8}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$
·56	·64	$\frac{7}{8}$	$3\frac{1}{2}$ × $3\frac{1}{2}$	$4\frac{1}{2}$
·64	·72	$\frac{7}{8}$	5 × 5	2 rows, 6 in each row
·72	·94	1	6 × 6	2 „ $5\frac{1}{2}$ „
·94	1·14	$1\frac{1}{8}$	7 × 7	2 „ $5\frac{1}{2}$ „
1·14	1·20	$1\frac{1}{4}$	8 × 8	2 „ 5 „

* The thickness of the stringer angle is to be that of the sheerstrake or stringer plate, whichever is the less.

TABLE 20

(SEE CONTINUATION)

LOWER DECKS

LENGTH L	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR ·1L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED)
			SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	
1	2	3	4	5	6	7	8
Feet	Feet	Inches	Square inches	Inches	Square inches	Inches	Inches
180	33	23	16	·28			·26
190	34	23¼	17	·28			·26
200	35	23½	18	·29			·26
210	36	23¾	19	·29			·26
220	37	24	21	·29			·26
230	38	24¼	23	·29			·26
240	39	24½	25	·30			·26
250	40	24¾	28	·30			·26
260	41	25	31	·30			·26
270	42	25¼	35	·30			·26
280	43	25½	38	·31			·26
290	44	25¾	42	·31			·26
300	45	26	46	·31			·26
310	46	26¼	50	·31			·26
320	47	26½	53	·32			·27
330	48	26¾	56	·32			·27
340	49	27	59	·32	53	·29	·27
350	50	27¼	62	·32	55	·29	·27
360	51	27½	64	·33	57	·30	·28
370	52	27¾	66	·33	59	·30	·28
380	53	28	68	·33	61	·30	·28
390	54	28¼	70	·33	63	·30	·28
400	55	28½	72	·34	65	·31	·29
410	56	28¾	75	·34	67	·31	·29
420	57	29	77	·34	69	·31	·29
430	58	29¼	80	·34	71	·31	·29
440	59	29½	82	·35	73	·32	·30
450	60	29¾	85	·35	75	·32	·30
460	61	30	88	·35	77	·32	·30
470	62	30¼	91	·36	79	·32	·30
480	63	30½	94	·36	82	·33	·30
490	64	30¾	97	·36	84	·33	·30
500	65	31	100	·37	87	·33	·31

For notes see page 105

LENGTH L	BASIC BREADTH B_b	BEAM SPACING AMIDSHIPS	SECOND DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		THIRD DECK PLATING OUTSIDE LINE OF OPENINGS FOR ·4L AMIDSHIPS		PLATING OF SECOND & THIRD DECKS INSIDE LINE OF OPENINGS & FOR ·1L FROM ENDS AND OF PLATFORM DECKS THROUGHOUT (UNSHEATHED)
			SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	SECTIONAL AREA	MINIMUM THICKNESS (UNSHEATHED)	
1	2	3	4	5	6	7	8
Feet	Feet	Inches	Square inches	Inches	Square inches	Inches	Inches
510	66	$31\frac{1}{4}$	104	·37	90	·34	·31
520	67	$31\frac{1}{2}$	107	·38	93	·34	·31
530	68	$31\frac{3}{4}$	110	·38	96	·34	·31
540	69	32	113	·39	99	·35	·31
550	70	$32\frac{1}{4}$	117	·39	102	·35	·31
560	71	$32\frac{1}{2}$	120	·40	105	·36	·32
570	72	$32\frac{3}{4}$	123	·40	107	·36	·32
580	73	33	126	·41	110	·37	·32
590	74	$33\frac{1}{4}$	129	·41	112	·37	·32
600	75	$33\frac{1}{2}$	132	·42	115	·38	·32
610	76	$33\frac{3}{4}$	135	·42	118	·38	·32
620	77	34	139	·43	121	·39	·33
630	78	$34\frac{1}{4}$	142	·43	124	·39	·33
640	79	$34\frac{1}{2}$	145	·44	128	·40	·33
650	80	$34\frac{3}{4}$	148	·44	132	·40	·33

NOTES.—TABLE 20

1. Sectional area.—The Table area of lower decks (cols. 4 and 6) is for one side of the ship outside the line of hatchways or other openings and inside the line of notches for 'tween deck frames; it includes overlapped seams, if fitted.

2. Corrections.

For breadth.

If B differs from B_b (col. 2) the area is to be modified in direct proportion.

For beam spacing.

If the spacing of beams fitted at every frame, or of longitudinals, differs from that in col. 3 the minimum thickness of deck plating (cols. 5 and 7) is to be modified at the rate of ·01 inch for every 2 inches of difference.

3. Stringer plates and angles.—The thickness of stringer plates may be the same as that of the deck plating. Angles connecting the deck to shell plating are to have the same thickness as the stringer or deck plating to which they are attached.

4. Sheathed decks.—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 5, 7 and 8 may be reduced by 10 per cent.

5. Decks with stringer and tie plates.— Stringer and tie plates fitted under a wood deck are to have the combined sectional area, for ·4L amidships, required for a plated deck.

The width of stringer plates from shell to inner edge, for ·4L amidships, is not to be less than 38 inches and 46 inches for lengths of 180 feet and 260 feet respectively with intermediate values in proportion. The width for ·1L from the ends is not to be less than 60 per cent of the width amidships.

The width of tie plates throughout is not to be less than 12 inches and 20 inches for lengths of 180 feet and 260 feet respectively with intermediate values in proportion.

The thickness of the stringer and tie plates throughout is not to be less than given in col. 5.

TABLE 21
(SEE CONTINUATION)

SHORT SUPERSTRUCTURES

LENGTH L	SIDE PLATING		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE
1	2	3	4	5	6	7	8	9	10	11
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
100	·22	·22	12	5	·22	·22	·22	·24	·24	·24
110	·22	·22	13	5	·22	·22	·22	·24	·24	·24
120	·22	·22	14	5	·22	·22	·22	·24	·24	·24
130	·22	·22	15	5	·22	·22	·22	·24	·24	·24
140	·23	·23	16	5	·23	·23	·23	·24	·24	·24
150	·23	·24	17	5	·23	·24	·24	·24	·24	·24
160	·24	·25	18	6	·24	·25	·25	·25	·25	·25
170	·24	·25	19	6	·24	·25	·25	·25	·25	·25
180	·25	·26	20	6	·25	·26	·26	·25	·25	·25
190	·25	·27	21	6	·25	·27	·27	·25	·25	·25
200	·26	·28	22	7	·26	·28	·28	·26	·26	·26
210	·26	·28	23	7	·26	·28	·28	·26	·26	·26
220	·27	·29	24	7	·27	·29	·29	·26	·26	·26
230	·27	·29	25	7	·27	·29	·29	·26	·26	·26
240	·28	·30	26	8	·28	·30	·30	·26	·27	·27
250	·28	·30	26	8	·28	·30	·30	·26	·27	·27
260	·29	·31	27	8	·29	·31	·31	·26	·27	·27
270	·29	·32	28	8	·29	·32	·32	·26	·27	·27
280	·30	·33	29	8	·30	·33		·27	·28	·28
290	·30	·33	29	8	·30	·33		·27	·28	·28
300	·31	·34	30	8	·31	·34		·27	·28	·28
310	·31	·35	31	8	·31	·35		·27	·28	·28
320	·32	·36	32	9	·32	·36		·27	·29	·29
330	·32	·36	32	9	·32	·36		·27	·29	·29
340	·33	·37	33	9	·33	·37		·28	·29	·29
350	·33	·37	33	9	·33	·37		·28	·29	·29
360	·34	·38	34	9	·34	·38		·28	·30	·30
370	·34	·38	34	9	·34	·38		·28	·30	·30
380	·35	·39	35	9	·35	·39		·28	·30	·30
390	·35	·39	35	9	·35	·39		·28	·30	·30
400	·36	·40	36	10	·36			·28	·31	·31
410	·36	·40	36	10	·36			·28	·31	·31
420	·37	·41	37	10	·37			·29	·31	·31
430	·37	·41	37	10	·37			·29	·31	·31
440	·38	·42	38	10	·38			·29	·32	·32
450	·38	·42	38	10	·38			·29	·32	·32
460	·39	·43	39	10	·39			·29	·32	·32
470	·39	·43	39	10	·39			·29	·32	·32
480	·40	·44	40	11	·40			·30	·33	·33
490	·40	·44	40	11	·40			·30	·33	·33
500	·41	·45	41	11	·41			·30	·33	·33

PLATED DECK REQUIRED

PLATED DECK REQUIRED

For notes see page 107

TABLE 21
(CONCLUDED)

LENGTH L	SIDE PLATING		WIDTH OF STRINGER AND TIE PLATES WITH WOOD DECK		THICKNESS OF STRINGER AND TIE PLATES WITH WOOD DECK			MINIMUM THICKNESS OF UNSHEATHED PLATED DECKS		
	POOP	BRIDGE & FORECASTLE	STRINGER	TIE PLATE	POOP	BRIDGE	FORECASTLE	POOP	BRIDGE	FORECASTLE
1	2	3	4	5	6	7	8	9	10	11
Feet	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
510	·41	·45	41	11	·41			·30	·33	·33
520	·42	·46	42	11	·42			·30	·34	·34
530	·42	·46	42	11	·42			·30	·34	·34
540	·43	·47	43	11	·43			·31	·34	·34
550	·43	·47	43	11	·43			·31	·34	·34
560	·44	·48	44	12	·44			·31	·35	·35
570	·44	·48	44	12	·44			·31	·35	·35
580	·45	·49	45	12	·45			·31	·35	·35
590	·45	·49	45	12	·45			·31	·35	·35
600	·46	·50	46	12	·46			·32	·36	·36
610	·46	·50	46	12	·46			·32	·36	·36
620	·47	·51	47	12	·47			·32	·36	·36
630	·47	·51	47	12	·47			·32	·36	·36
640	·48	·52	48	12	·48			·32	·37	·37
650	·48	·52	48	12	·48			·32	·37	·37

PLATED DECK REQUIRED

NOTES.—TABLE 21

1. Sheathed decks.—Where plated decks are sheathed with wood or approved composition the thickness given in cols. 9, 10 and 11 may be reduced by 10 per cent.

2. Allowance for height of platform.—If the draught desired is not greater than ·7D (D being measured to the uppermost continuous deck) all thicknesses given in the Table may be reduced by 10 per cent.

3. Stringer angles.—Angles connecting the deck to shell plating are to have the same thickness as required for plated decks, cols. 9, 10 and 11.

TABLE 22 END BULKHEADS OF SUPERSTRUCTURES

Stiffeners spaced 30 inches apart

BULKHEADS AT THE FORE END OF BRIDGES, OF UNPROTECTED POOPS THE LENGTH OF WHICH IS ·4L OR MORE AND OF ALL POOPS PROTECTING MACHINERY OPENINGS

LENGTH L	BULB ANGLE STIFFENERS	RIVETS IN END LUGS		PLATING
		Number	Diameter	
Feet	Inches ^{3} *Modulus—Inches*		Inches	Inches
Under 160	$5\frac{1}{2} \times 3 \times \cdot34$ *5·60*	3	$\frac{5}{8}$	·30
160	$6 \times 3 \times \cdot35$ *6·95*	3	$\frac{5}{8}$	·30
200	$6 \times 3 \times \cdot45$ *8·35*	4	$\frac{5}{8}$	·30
240	$7 \times 3 \times \cdot37$ *10·10*	4	$\frac{5}{8}$	·33
280	$7 \times 3 \times \cdot48$ *12·05*	4	$\frac{3}{4}$	·36
320	$8 \times 3 \times \cdot40$ *14·30*	5	$\frac{3}{4}$	·39
360	$8 \times 3 \times \cdot49$ *16·35*	5	$\frac{3}{4}$	·42
400	$9 \times 3\frac{1}{2} \times \cdot41$ *19·15*	5	$\frac{3}{4}$	·44
440	$9 \times 3\frac{1}{2} \times \cdot51$ *21·90*	5	$\frac{3}{4}$	·44
480	$10 \times 3\frac{1}{2} \times \cdot42$ *24·80*	5	$\frac{3}{4}$	·44
520	$10 \times 3\frac{1}{2} \times \cdot53$ *28·45*	6	$\frac{3}{4}$	·44
560	$11 \times 3\frac{1}{2} \times \cdot45$ *31·95*	6	$\frac{3}{4}$	·44

BULKHEADS OF POOPS PARTIALLY PROTECTED OR LESS IN LENGTH THAN ·4L AND NOT PROTECTING MACHINERY OPENINGS

LENGTH L	ANGLE STIFFENERS	RIVETS IN END LUGS		PLATING
		Number	Diameter	
Feet	Inches ^{3} *Modulus—Inches*		Inches	Inches
Under 150	$3 \times 2\frac{1}{2} \times \cdot30$ *1·00*	2	$\frac{5}{8}$	·24
150	$3\frac{1}{2} \times 2\frac{1}{2} \times \cdot32$ *1·40*	2	$\frac{5}{8}$	·24
200	$4 \times 3 \times \cdot34$ *1·90*	2	$\frac{5}{8}$	·26
250	$4 \times 3 \times \cdot46$ *2·50*	2	$\frac{5}{8}$	·29
300	$5 \times 3 \times \cdot38$ *3·15*	3	$\frac{5}{8}$	·32
350	$6 \times 3 \times \cdot35$ *4·20*	3	$\frac{5}{8}$	·35
400	$6 \times 3 \times \cdot44$ *5·20*	3	$\frac{3}{4}$	·38
450	$7 \times 3\frac{1}{2} \times \cdot40$ *6·35*	3	$\frac{3}{4}$	·38
500	$7 \times 3\frac{1}{2} \times \cdot48$ *7·55*	4	$\frac{3}{4}$	·38
550	$7 \times 3\frac{1}{2} \times \cdot50$ *7·80*	4	$\frac{3}{4}$	·38

BULKHEADS AT AFTER ENDS OF BRIDGES AND FORECASTLES

LENGTH L	ANGLE STIFFENERS	PLATING
Feet	Inches ^{3} *Modulus—Inches*	Inches
Under 150	$2\frac{1}{2} \times 2\frac{1}{2} \times \cdot26$ *·60*	·20
150	$3 \times 2\frac{1}{2} \times \cdot28$ *·90*	·20
250	$3\frac{1}{2} \times 3 \times \cdot30$ *1·30*	·24
350	$4 \times 3 \times \cdot32$ *1·80*	·28
400 and above	$4 \times 3 \times \cdot40$ *2·20*	·30

Stiffeners to overlap, and be riveted to boundary angles

Section moduli above are given to nearest ·05

NOTES.—TABLE 22

1. Correction for spacing of stiffeners.—If the spacing of stiffeners differs from 30 inches, modulus of stiffeners is to be modified in direct proportion.

If the spacing of the stiffeners is greater than 30 inches, the thickness of plating is to be increased at the rate of ·01 inch for every 2 inches increase in spacing.

2. Allowance for height of platform.—When the draught d does not exceed ·7D, D being measured to the uppermost continuous deck, the scantlings given in the Table may be modified as follows :—

THICKNESS OF PLATING.

Where L = 200 feet or less, thickness may be 90 per cent of Table thickness.

Where L = 400 feet or above, thickness may be 85 per cent of Table thickness.

MODULUS OF STIFFENERS.

Where L = 200 feet or less, modulus may be 75 per cent of Table modulus.

Where L = 400 feet or above, modulus may be 70 per cent of Table modulus.

For intermediate lengths the percentage may be obtained by interpolation.

3. Bulkheads at the fore ends of bridges which do not cover deck openings are to have plating as required by the Table, but the modulus of the stiffeners may be reduced by 10 per cent.

4. Particulars of sections and moduli are given in Table 56.

DECKHOUSES

LOWER TIER

Stiffeners spaced 30 inches apart

LENGTH L	FRONTS		SIDES		CORRECTION PER FOOT DIFFERENCE IN DRAUGHT (See NOTE 1)	
	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING
Feet	Inches *Modulus—Inches³* ANGLES	Inches	Inches *Modulus—Inches³* ANGLES	Inches	Per cent	Per cent
200	4 × 3 × ·41 *2·25*	·26	$3\frac{1}{2}$ × 3 × ·32 *1·40*	·25	10	6
300	5 × 3 × ·35 *2·95*	·28	4 × 3 × ·30 *1·65*	·26	25	8
400	5 × 3 × ·46 *3·80*	·30	4 × 3 × ·36 *2·00*	·28	40	10
500	6 × 3 × ·45 *5·30*	·32	5 × 3 × ·32 *2·65*	·30	50	11
600	6 × 3 × ·60 *6·95*	·34	$5\frac{1}{2}$ × 3 × ·34 *3·46*	·32	50	12

UPPER TIER

Stiffeners spaced 30 inches apart

LENGTH L	FRONTS		SIDES		CORRECTION PER FOOT DIFFERENCE IN DRAUGHT (See NOTE 1)	
	STIFFENERS	PLATING	STIFFENERS	PLATING	STIFFENERS	PLATING
Feet	Inches *Modulus—Inches³* ANGLES	Inches	Inches *Modulus—Inches³* ANGLES	Inches	Per cent	Per cent
200	3 × $2\frac{1}{2}$ × ·26 *·85*	·24	$2\frac{1}{2}$ × $2\frac{1}{2}$ × ·30 *·70*	·23	10	5
300	3 × $2\frac{1}{2}$ × ·32 *1·10*	·24	3 × $2\frac{1}{2}$ × ·28 *·90*	·23	15	6
400	$3\frac{1}{2}$ × 3 × ·32 *1·40*	·26	3 × 3 × ·36 *1·20*	·24	20	7
500	4 × 3 × ·34 *1·90*	·28	$3\frac{1}{2}$ × 3 × ·36 *1·55*	·26	25	8
600	4 × 3 × ·46 *2·50*	·30	4 × 3 × ·36 *2·00*	·28	30	9

For notes see page 111

TABLE 23
(SEE CONTINUATION)

BEAMS WITH PLATED DECK

Spaced 30 inches apart

LENGTH L	SPAN FEET					
	10		15		20	
Feet	INCHES *Modulus—Inches³*					
200	ANGLES	$3\times2\frac{1}{2}\times\cdot28$ *·90*	ANGLES	$4\times3\times\cdot36$ *2·00*	ANGLES	$5\times3\times\cdot42$ *3·50*
300		$3\frac{1}{2}\times3\times\cdot32$ *1·35*		$5\times3\times\cdot30$ *2·55*		$6\times3\times\cdot34$ *4·10*
400		$4\times3\times\cdot32$ *1·75*		$5\times3\times\cdot37$ *3·10*	BULB ANGLES	$5\times3\times\cdot40$ *5·15*
500		$4\frac{1}{2}\times3\times\cdot30$ *2·05*		$5\times3\times\cdot44$ *3·65*		$5\times3\times\cdot45$ *5·65*
600		$4\frac{1}{2}\times3\times\cdot38$ *2·60*		$6\times3\times\cdot36$ *4·30*		$6\times3\times\cdot30$ *6·25*

DECK PLATING

ABOVE DECKHOUSES

LENGTH L	AREA OF DECK ABOVE LONG HOUSES — PERCENTAGE OF AREA OF STRENGTH DECK ASSUMING TWO DECKS FITTED	MINIMUM THICKNESS OF DECK PLATING (*See* NOTE 9)	
		UNSHEATHED	SHEATHED
1	2	3	4
Feet	Per cent	Inches	Inches
200	60	·24	·20
300	50	·25	·22
400	40	·26	·23
500	35	·28	·24
550	30	·30	·25

For notes see page 111

TABLE 23.—NOTES

1. Draught.—The Table is directly applicable when the ratio d/D = ·70, D being measured to the deck upon which the lowest tier of deckhouses is situated.

If the draught is $\frac{\text{greater}}{\text{less}}$ than that corresponding to the above ratio the modulus of the stiffeners and the thickness of the plating of the deckhouse fronts and sides are to be $\frac{\text{increased}}{\text{reduced}}$ by the percentages given in this Table, subject to a maximum increase of 100 per cent and a maximum reduction of 20 per cent in modulus and subject to a maximum reduction of 10 per cent in the thickness of the plating.

2. Spacing of stiffeners.—If the spacing of the stiffeners differs from 30 inches, the modulus of the stiffeners is to be modified in direct proportion. The thickness of the plating is to be increased at the rate of ·01 inch for every 3 inches increase in spacing.

3. Single tier deckhouses.—For deckhouses not having an upper tier of houses the modulus of stiffeners of the sides and aft end may, after correction for draught, be reduced by 15 per cent except where d/D exceeds ·70.

4. Breadth of deckhouse fronts.—The Table is directly applicable, subject to the above corrections, to deckhouse fronts which are ·75B or more in breadth.

When the breadth of a partially protected house front is ·25B or less, the scantlings may be as required for sides; when the breadth is intermediate between these limits the scantlings may be obtained by interpolation.

5. Flush deck ships, and those with forecastles, or forecastles and poops, having minimum freeboards.—The modulus of stiffeners at the fronts of houses in these ships is, after correction, to be increased by 100 per cent, and two webs are to be arranged.

The corrected thickness of the front plating is to be increased 5 per cent.

6. After ends of houses.—The modulus of the stiffeners is to be 70 per cent of that of the side stiffeners and the thickness of the plating is to be 90 per cent of that of the side plating based on 30 inch spacing. Unprotected deckhouses at after ends of ships will be specially considered.

7. End connections of stiffeners.—Stiffeners at fronts of deckhouses are to be lugged except at the upper tier when L is less than 500 ft. Stiffeners at sides of lower tier are to be bracketed if there are two tiers, and lugged if there is only one tier; those at upper tiers are to be lugged when L exceeds 500 ft. Stiffeners at aft ends of deckhouses may be unattached. If stiffeners are welded to the deck, brackets may be omitted, provided the section modulus of the stiffeners is increased by 20 per cent.

8. Beams.—The Table is directly applicable to the beams of a lower deckhouse having superimposed houses. If there are no superimposed houses the modulus of the beam may be reduced by 20 per cent.

The modulus of the beams of the upper tier may be 20 per cent less than required by the Table and if there is a third tier the beams of that tier may be 40 per cent less than required by the Table.

If the beam spacing differs from 30 inches the modulus of the beams is to be modified in direct proportion.

9. Deck plating above houses.—Where the length of a deckhouse exceeds ·15L, deck plating of the sectional area derived from the Table is to be fitted at the top of the house.

The two decks referred to in col. 2 are the decks of the main hull as used in Table 18.

If there are two tiers of houses the sectional area of the top of each may be 80 per cent of the area derived from the Table, or alternatively the top of the upper tier may be 75 per cent, and of the lower tier 100 per cent of that area.

The minimum thicknesses of plating given in cols. 3 and 4 apply to decks outside deckhouses and outside line of openings; within the line of openings the thicknesses may be reduced by 10 per cent. Inside deckhouses the thicknesses may be reduced by a further 10 per cent.

The thickness of unsheathed plating (col. 3) is to be increased by ·01 inch for each 3 inch increase of spacing above 36 inches.

10. Where the height of deckhouses exceeds 9 feet the scantlings will be specially considered.

11. Exposed machinery casings.—The thickness of the plating and the modulus of the stiffeners are to be 20 per cent greater than those for deckhouses in the same position.

12. Particulars of sections and moduli are given in Table 56.

TABLE 24

BREADTH B	BEAM SPACING	CORRECTION FACTOR K		UNSUPPORTED SPAN FEET 6	8	10	12	14	16
Feet	Inches			INCHES *Modulus—Inches³*					
24	21	1·20	ANGLES	3 × 2½ × ·30 *1·00*	3 × 2½ × ·38 *1·25*	3½ × 3 × ·34 *1·45*	3½ × 3 × ·39 *1·70*		
28	22	1·20	ANGLES	3 × 2½ × ·34 *1·15*	3½ × 3 × ·32 *1·40*	3½ × 3 × ·37 *1·60*	3½ × 3 × ·44 *1·90*	4 × 3 × ·42 *2·30*	
32	23	1·20	ANGLES	3½ × 3 × ·32 *1·40*	3½ × 3 × ·38 *1·65*	3½ × 3 × ·44 *1·90*	4 × 3 × ·39 *2·15*	4 × 3 × ·48 *2·65*	5 × 3 × ·3 *3·10*
36	24	1·20	ANGLES		4 × 3 × ·38 *2·10*	4 × 3 × ·44 *2·40*	5 × 3 × ·32 *2·70*	5 × 3 × ·41 *3·40*	6 × 3 × ·3 *4·00*
40	25	1·20	ANGLES		5 × 3 × ·34 *2·85*	5 × 3 × ·39 *3·25*	5 × 3 × ·44 *3·65*	6 × 3 × ·37 *4·40*	5½ × 3 × ·3 *5·40*
44	26	1·20	ANGLES			6 × 3 × ·38 *4·55*	5 × 3 × ·39 *5·05*	5½ × 3 × ·36 *5·80*	6 × 3 × ·3 *7·10*
48	27	1·20	BULB ANGLES			5½ × 3 × ·38 *6·05*	6 × 3½ × ·34 *6·85*	6 × 3½ × ·41 *7·80*	6 × 3½ × ·4 *8·80*
52	28	1·20	BULB ANGLES			6 × 3½ × ·41 *7·80*	6 × 3½ × ·48 *8·80*	7 × 3½ × ·35 *9·80*	7 × 3½ × ·4 *10·95*
56	29	1·16	BULB ANGLES				7 × 3½ × ·41 *10·80*	7 × 3½ × ·47 *11·85*	*13·05*
60	30	1·12	BULB ANGLES				7 × 3½ × ·51 *12·65*	8 × 3½ × ·38 *13·85*	8 × 3½ × ·4 *15·05*
64	31	1·08	BULB ANGLES				8 × 3½ × ·41 *14·60*	8 × 3½ × ·46 *15·75*	8 × 3½ × ·5 *17·15*
68	32	1·04	BULB ANGLES				8 × 3½ × ·48 *16·20*	8 × 3½ × ·53 *17·40*	9 × 3½ × ·4 *18·90*
72	33	1·00	BULB ANGLES				8 × 3½ × ·53 *17·40*	9 × 3½ × ·40 *18·90*	9 × 3½ × ·4 *20·50*
76	34	1·00	BULB ANGLES				*18·20*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·5 *21·60*
80	35	1·00	BULB ANGLES				9 × 3½ × ·41 *19·15*	9 × 3½ × ·47 *20·80*	9 × 3½ × ·5 *22·70*

Section moduli above

NOTES.—TABLE 24

1. Application to various decks.—(*a*) The modulus given in the Table applies to weather deck beams in ships having a ratio of d/D not exceeding ·7 (D being measured to the uppermost continuous deck) with the exception of the following :—

(1) Single deck ships – – – (*see* (*d*))
(2) Short bridges and poops – – (*see* (*f*))
(3) Forecastle decks – – – (*see* (*g*))
(4) The forward ·12L of weather decks (*see* (*g*))

(*b*) When d/D is ·85 or greater the modulus for weather deck beams (except as qualified by (*d*) to (*g*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between ·7 and ·85 the correction factor is to be found by interpolation between 1·0 for d/D = ·7 and the Table factor K for d/D = ·85.

(*d*) Single deck ships. The modulus is to be obtained in accordance with the above notes and increased by 20 per cent.

(*e*) Bridges forming an effective superstructure as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*f*) Short bridges and poops. The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*g*) Forecastles and weather decks. For the forward ·075L the Table Modulus is to be multiplied by the factor

UNSUPPORTED SPAN FEET						CORRECTION FACTOR K	BEAM SPACING	BREADTH B
18	20	22	24	26				
INCHES *Modulus—Inches³*							Inches	Feet
					ANGLES	1·20	21	24
					ANGLES	1·20	22	28
					ANGLES	1·20	23	32
6 × 3 × ·41 *4·90*					ANGLES	1·20	24	36
5½×3 × ·41 *6·40*	6 × 3 × ·40 *7·65*				BULB ANGLES	1·20	25	40
6 × 3 × ·44 *8·20*	7 × 3 × ·35 *9·80*	7 × 3 × ·46 *11·65*			BULB ANGLES	1·20	26	44
7 × 3½×·37 *10·15*	7 × 3½×·46 *11·65*	8 × 3½×·37 *13·65*	8 × 3½×·46 *15·75*		BULB ANGLES	1·20	27	48
7 × 3½×·49 *12·25*	8 × 3½×·38 *13·85*	8 × 3½×·46 *15·75*	8 × 3½×·55 *17·85*	9 × 3½×·45 *20·20*	BULB ANGLES	1·20	28	52
8 × 3½×·40 *14·35*	8 × 3½×·47 *16·00*	8 × 3½×·56 *18·05*	9 × 3½×·45 *20·20*	9 × 3½×·53 *22·45*	BULB ANGLES	1·16	29	56
8 × 3½×·49 *16·45*	8 × 3½×·56 *18·05*	9 × 3½×·45 *20·20*	9 × 3½×·54 *22·70*	10 × 3½×·44 *25·45*	BULB ANGLES	1·12	30	60
9 × 3½×·39 *18·65*	9 × 3½×·45 *20·20*	9 × 3½×·54 *22·70*	10 × 3½×·43 *25·15*	10 × 3½×·52 *28·10*	BULB ANGLES	1·08	31	64
9 × 3½×·46 *20·50*	9 × 3½×·53 *22·45*	10 × 3½×·42 *24·80*	10 × 3½×·51 *27·75*	 *31·00*	BULB ANGLES	1·04	32	68
9 × 3½×·52 *22·20*	10 × 3½×·41 *24·50*	10 × 3½×·49 *27·10*	10 × 3½×·58 *30·10*	11 × 3½×·48 *33·05*	BULB ANGLES	1·00	33	72
9 × 3½×·57 *23·60*	10 × 3½×·45 *25·80*	10 × 3½×·53 *28·45*	11 × 3½×·44 *31·55*	11 × 3½×·52 *34·55*	BULB ANGLES	1·00	34	76
10 × 3½×·41 *24·50*	10 × 3½×·48 *26·80*	10 × 3½×·57 *29·80*	11 × 3½×·47 *32·70*	11 × 3½×·55 *35·80*	BULB ANGLES	1·00	35	80

given to nearest ·05

NOTES.—TABLE 24 *(concluded).*

1·2K irrespective of draught. Between ·075L and ·12L from forward, the Table Modulus is to be multiplied by the factor K, irrespective of draught.

2. Span for use in the Table is to be measured in feet from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. Corrections to modulus of beams.

FOR BEAM SPACING.

If the spacing at any point differs from that given in the Table the modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers of quarters, respectively, but need not exceed the modulus of beams derived from Table 25 and note 3 to that Table.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

6. Timber Deck Cargoes. Where timber load lines are to be assigned the Table Modulus is to be multiplied by the factor K, irrespective of draught. In single deck ships the increase of 20 per cent is to be applied.

TABLE 25

BEAMS AT CARGO AN

BREADTH B	BEAM SPACING	CORRECTION FACTOR C		UNSUPPORTED SPAN FEET 6	8	10	12	14	16
Feet	Inches			INCHES *Modulus—Inches*³					
24	21	·50	ANGLES	3 × 2½ × ·34 *1·15*	3½ × 3 × ·43 *1·85*	4 × 3 × ·48 *2·65*	5 × 3 × ·41 *3·40*		
28	22	·50	ANGLES	3 × 2½ × ·34 *1·15*	3½ × 3 × ·43 *1·85*	*2·80*	5 × 3 × ·45 *3·75*	6 × 3 × ·39 *4·65*	
32	23	·50	ANGLES		4 × 3 × ·36 *2·00*	5 × 3 × ·37 *3·10*	6 × 3 × ·35 *4·20*	5½ × 3 × ·30 *5·15*	5½ × 3 × ·40 *6·25*
36	24	·50	ANGLES		4 × 3 × ·40 *2·20*	5 × 3 × ·41 *3·40*	6 × 3 × ·39 *4·65*	5½ × 3 × ·38 *6·05*	6 × 3 × ·39 *7·50*
40	25	·50	ANGLES		4 × 3 × ·43 *2·35*	5 × 3 × ·44 *3·65*	5½ × 3 × ·31 *5·30*	5½ × 3 × ·46 *6·95*	6 × 3 × ·49 *8·90*
44	26	·55	ANGLES		5 × 3 × ·30 *2·55*	6 × 3 × ·34 *4·10*	5½ × 3 × ·37 *5·95*	6 × 3 × ·42 *7·90*	7 × 3 × ·38 *10·25*
48	27	·60	ANGLES		5 × 3½ × ·32 *2·70*	6 × 3½ × ·38 *4·50*	6 × 3½ × ·31 *6·50*	6 × 3½ × ·48 *8·80*	7 × 3½ × ·48 *11·50*
52	28	·65	ANGLES		5 × 3½ × ·34 *2·85*	6 × 3½ × ·42 *4·95*	6 × 3½ × ·37 *7·25*	7 × 3½ × ·36 *9·95*	7 × 3½ × ·50 *12·80*
56	29	·70	BULB ANGLES				6 × 3½ × ·43 *8·10*	7 × 3½ × ·42 *10·95*	8 × 3½ × ·38 *14·10*
60	30	·75	BULB ANGLES				6 × 3½ × ·50 *9·05*	7 × 3½ × ·49 *12·25*	8 × 3½ × ·44 *15·25*
64	31	·80	BULB ANGLES				7 × 3½ × ·39 *10·45*	8 × 3½ × ·37 *13·65*	8 × 3½ × ·50 *16·70*
68	32	·85	BULB ANGLES				7 × 3½ × ·48 *12·05*	8 × 3½ × ·43 *15·05*	8 × 3½ × ·50 *18·05*
72	33	·90	BULB ANGLES				8 × 3½ × ·39 *14·10*	8 × 3½ × ·50 *16·70*	9 × 3½ × ·43 *19·65*
76	34	·90	BULB ANGLES					9 × 3½ × ·39 *18·65*	9 × 3½ × ·48 *21·05*
80	35	·90	BULB ANGLES					9 × 3½ × ·47 *20·80*	9 × 3½ × ·54 *22·70*

Section moduli above

NOTES.—TABLE 25

1. Application to various decks.—(*a*) Cargo decks. The modulus of the beams is to be determined directly from the Table and corrected as required below.

(*b*) Accommodation decks. The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.

2. Span for use in the Table is to be measured from girder to girder or from girder to a point midway between the toe of the bracket and the inner edge of the frame.

3. Corrections to modulus of beams.

FOR BEAM SPACING.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

UNSUPPORTED SPAN FEET 18	20	22	24	26		CORRECTION FACTOR C	BEAM SPACING	BREADTH B
INCHES *Modulus—Inches*³							Inches	Feet
					ANGLES	·50	21	24
					ANGLES	·50	22	28
					BULB ANGLES	·50	23	32
6 × 3 × ·51 *9·15*					BULB ANGLES	·50	24	36
7 × 3 × ·43 *11·15*	7 × 3 × ·56 *13·50*				BULB ANGLES	·50	25	40
7 × 3 × ·53 *13·00*	8 × 3 × ·47 *15·90*	9 × 3½ × ·40 *18·90*			BULB ANGLES	·55	26	44
8 × 3½ × ·41 *14·60*	8 × 3½ × ·55 *17·85*	9 × 3½ × ·49 *21·35*	10 × 3½ × ·43 *25·15*		BULB ANGLES	·60	27	48
8 × 3½ × ·48 *16·20*	9 × 3½ × ·42 *19·40*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·59 *30·45*	BULB ANGLES	·65	28	52
8 × 3½ × ·54 *17·60*	9 × 3½ × ·47 *20·80*	10 × 3½ × ·40 *24·20*	10 × 3½ × ·52 *28·10*	11 × 3½ × ·45 *31·95*	BULB ANGLES	·70	29	56
9 × 3½ × ·39 *18·65*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·48 *33·05*	BULB ANGLES	·75	30	60
9 × 3½ × ·44 *19·90*	9 × 3½ × ·56 *23·30*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·59 *30·45*	11 × 3½ × ·52 *34·55*	BULB ANGLES	·80	31	64
9 × 3½ × ·48 *21·05*	10 × 3½ × ·40 *24·20*	10 × 3½ × ·51 *27·75*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·55 *35·80*	BULB ANGLES	·85	32	68
9 × 3½ × ·53 *22·45*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·55 *29·15*	11 × 3½ × ·47 *32·70*	11 × 3½ × ·58 *37·00*	BULB ANGLES	·90	33	72
9 × 3½ × ·57 *23·60*	10 × 3½ × ·47 *26·45*	10 × 3½ × ·58 *30·10*	11 × 3½ × ·50 *33·80*	11 × 3½ × ·61 *38·20*	BULB ANGLES	·90	34	76
10 × 3½ × ·42 *24·80*	10 × 3½ × ·51 *27·75*	*31·15*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·63 *39·00*	BULB ANGLES	·90	35	80

given to nearest ·05

NOTES.—TABLE 25 (*concluded*)

FOR 'TWEEN DECK HEIGHT.

If the 'tween deck height in cargo spaces differs from 8 feet 6 inches, modulus is to be modified **in direct proportion.**

FOR HANGING CARGOES.

If the beams carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent of the beam modulus required for an 8 feet 6 inches 'tween deck for one, two or three tiers respectively. For accommodation decks the increase in the modulus for hanging cargo is to be the same as required above for cargo decks.

FOR BEAMS WITHOUT PLATING.

Where a plated deck is not fitted, the modulus of the beam is to be increased by 30 per cent for use in Table 56.

4. **For width of faying flanges** *see* D 3202.

5. **Particulars of sections and moduli are given in** Table 56.

TABLE 26 LONGITUDINALS AT WEATHER DECKS

LENGTH L	SPACING OF LONGITUDINALS	CORRECTION FACTOR K	UNSUPPORTED SPAN FEET				
			6	8	10	12	
Feet	Inches		INCHES *Modulus—Inches³*				
160	27½	1·20	5 × 3 × ·30 *2·55*	5 × 3 × ·39 *3·25*			ANGLES
180	28	1·20	5 × 3 × ·33 *2·80*	5 × 3 × ·41 *3·40*			
200	28½	1·20	5 × 3 × ·36 *3·00*	5 × 3 × ·44 *3·65*			
220	29	1·20	5 × 3 × ·39 *3·25*	5 × 3 × ·46 *3·80*			
240	29½	1·20	5 × 3 × ·41 *3·40*	5 × 3 × ·48 *3·95*			
260	30	1·20	5 × 3 × ·44 *3·65*	6 × 3 × ·35 *4·20*			
280	30½	1·20	5 × 3 × ·46 *3·80*	6 × 3 × ·37 *4·40*	6 × 3 × ·42 *5·00*		
300	31	1·20	5 × 3 × ·48 *3·95*	6 × 3 × ·39 *4·65*	5 × 3 × ·41 *5·25*	5½ × 3 × ·37 *5·95*	ANGLES
320	31½	1·20	6 × 3 × ·35 *4·20*	5½ × 3 × ·30 *5·15*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	
340	32	1·20	6 × 3 × ·37 *4·40*	5½ × 3 × ·34 *5·60*	6 × 3 × ·34 *6·80*	6 × 3 × ·43 *8·05*	
360	32½	1·20	6 × 3½ × ·39 *4·65*	6 × 3½ × ·28 *6·10*	6 × 3½ × ·40 *7·65*	6 × 3½ × ·50 *9·05*	
380	33	1·18	6 × 3½ × ·41 *4·85*	6 × 3½ × ·32 *6·60*	6 × 3½ × ·45 *8·35*	7 × 3½ × ·38 *10·25*	
400	33½	1·16	6 × 3½ × ·43 *5·05*	6 × 3½ × ·36 *7·10*	*9·20*	7 × 3½ × ·44 *11·30*	
420	34	1·14		6 × 3½ × ·40 *7·65*	7 × 3½ × ·36 *9·95*	7 × 3½ × ·50 *12·45*	BULB ANGLES
440	34½	1·12		6 × 3½ × ·44 *8·20*	7 × 3½ × ·41 *10·80*	8 × 3½ × ·36 *13·45*	
460	35	1·10		6 × 3½ × ·47 *8·65*	7 × 3½ × ·46 *11·65*	8 × 3½ × ·41 *14·60*	
480	35½	1·08		*9·20*	7 × 3½ × ·50 *12·45*	8 × 3½ × ·46 *15·75*	
500	36	1·06		7 × 3½ × ·34 *9·65*	*13·00*	8 × 3½ × ·50 *16·70*	

Section moduli above are given to nearest ·05

NOTES.—TABLE 26

1. Application to various decks.—(*a*) The modulus given in the Table applies to weather deck longitudinals, outside the line of deck openings, in ships having a ratio of d/D not exceeding ·7 (D being measured to the uppermost continuous deck) with the exception of the following :—

Short bridges ... ... (*see* (*e*))

(*b*) When d/D is ·85 or greater the modulus for weather deck longitudinals (except as qualified by (*d*) to (*i*)) is to be the Table modulus multiplied by the factor K given in the third column.

(*c*) When d/D lies between ·7 and ·85 the correction factor is to be found by interpolation between 1·0 for d/D=·7 and the Table factor K for d/D=·85.

(*d*) Bridges forming an effective superstructure as defined in D 206. The modulus is to be taken directly from the Table without the use of the factor K.

(*e*) Short bridges. The modulus taken directly from the Table without the use of the factor K may be reduced by 30 per cent.

(*f*) Outside the line of openings the modulus derived as above is to be maintained for ·4L amidships and may be gradually reduced to 70 per cent of the midship value at ·1L from the after end and to 85 per cent at ·12L from the fore end.

(*g*) Within the line of openings abaft ·12L from forward the modulus may be 70 per cent of that required outside the line of openings amidships.

(*h*) For the forward ·075L of forecastles and weather decks, the Table Modulus is to be multiplied by the factor 1·2K irrespective of draught. Between ·075L and ·12L from forward the Table Modulus is to be multiplied by the factor K irrespective of draught.

2. Span for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.

3. Corrections to modulus of longitudinals.

FOR SPACING OF LONGITUDINALS.

If the spacing at any point differs from the spacing given in the Table, modulus is to be modified in direct proportion.

FOR HANGING CARGOES.

If the longitudinals carry hanging cargo, such as chilled beef, the modulus is to be increased by 50 and 100 per cent for one or two tiers of quarters, respectively, but need not exceed the modulus of longitudinals derived from Table 27 and note 3 to that Table.

4. For width of faying flanges *see* D 3202.

5. Particulars of sections and moduli are given in Table 56.

TABLE 27 LONGITUDINALS AT CARGO AND ACCOMMODATION DECKS

LENGTH L	SPACING OF LONGITUDINALS	CORRECTION FACTOR C	UNSUPPORTED SPAN FEET				
			6	8	10	12	
Feet	Inches		INCHES Modulus—Inches³				
160	27½	·50	3½×3×·35 *1·50*	5×3×·29 *2·40*			ANGLES
180	28	·50	4×3×·29 *1·60*	5×3×·30 *2·55*			
200	28½	·50	4×3×·32 *1·80*	5×3×·33 *2·80*			
220	29	·50	4×3×·35 *1·95*	5×3×·35 *2·95*			
240	29½	·50	4×3×·39 *2·15*	5×3×·38 *3·15*			
260	30	·50	4×3×·44 *2·40*	5×3×·41 *3·40*			
280	30½	·50	5×3×·32 *2·70*	5×3×·45 *3·75*	6×3×·38 *4·55*		
300	31	·55	5×3×·36 *3·00*	5×3×·48 *3·95*	6×3×·41 *4·85*	5½×3×·37 *5·95*	ANGLES
320	31½	·60	5×3×·40 *3·30*	6×3×·36 *4·30*	5×3×·42 *5·35*	5½×3×·41 *6·40*	
340	32	·62	5×3×·44 *3·65*	6×3×·40 *4·75*	5½×3×·36 *5·80*	6×3×·35 *6·95*	
360	32½	·65	6×3×·34 *4·10*	5×3×·40 *5·15*	5½×3×·40 *6·25*	6×3×·38 *7·35*	
380	33	·67	6×3×·37 *4·40*	5½×3×·34 *5·60*	5½×3×·44 *6·70*	6×3×·42 *7·90*	
400	33½	·70	6×3½×·40 *4·70*	5½×3×·37 *5·95*	6×3½×·36 *7·10*	6×3½×·45 *8·35*	BULB ANGLES
420	34	·72		6×3½×·30 *6·35*	6×3½×·40 *7·65*	6×3½×·49 *8·95*	
440	34½	·75		6×3½×·34 *6·85*	6×3½×·43 *8·10*	*9·40*	
460	35	·77		6×3½×·37 *7·25*	6×3½×·46 *8·50*	7×3½×·36 *9·95*	
480	35½	·80		6×3½×·40 *7·65*	6×3½×·50 *9·05*	7×3½×·39 *10·45*	
500	36	·82		6×3½×·42 *7·95*	*9·45*	7×3½×·42 *10·95*	BULB ANGLES

Section moduli above are given to nearest ·05

NOTES.—TABLE 27

1. Application to various decks.—(*a*) For all cargo decks the modulus of the deck longitudinals is to be determined directly from the Table and corrected as required below.
   (*b*) Accommodation decks. The modulus derived from (*a*) is to be multiplied by the factor C given in the third column of the Table.
2. Span for use in the Table is to be measured from transverse to transverse or from transverse to a point midway between the toe of the end bracket and the bulkhead.
3. Corrections to modulus of longitudinals.
   FOR SPACING OF LONGITUDINALS.
   If the spacing at any point differs from the spacing given in the Table modulus is to be modified in direct proportion.
   FOR 'TWEEN DECK HEIGHT.
   If the 'tween deck height in cargo spaces differs from 8 feet 6 inches modulus is to be modified in direct proportion.
   FOR HANGING CARGOES.
   If the longitudinals carry hanging cargo, such as chilled beef, and may be simultaneously loaded above with cargo, the modulus is to be increased by 30, 60 and 90 per cent of the modulus of longitudinal required for an 8 feet 6 inches 'tween deck for one, two or three tiers respectively. For accommodation decks the increase in the modulus for hanging cargo is to be the same as required above for cargo decks.
4. For width of faying flanges *see* D 3202.
5. Particulars of sections and moduli are given in Table 56.

BEAM KNEES AND END BRACKETS OF DECK LONGITUDINALS

1. **Beam knees.** At decks where the hold frames terminate, and at the lower deck in the panting region, the dimensions of beam knees are to be based on the modulus of frame or beam, whichever is greater. At all other decks, except as indicated in 5 below, the dimensions are to be based on the modulus of the beam.

Knees are to be flanged when the modulus exceeds 36 inches^3 and the width of the flange is not to be less than $\frac{\sqrt{\text{modulus}}}{3}$ inches with a minimum of 2 inches.

The thickness in inches of unflanged knees is not to be less than $0{\cdot}16 + \frac{\sqrt{\text{modulus}}}{20}$ and of flanged knees $0{\cdot}08 + \frac{\sqrt{\text{modulus}}}{20}$ with a minimum of ·28 inch.

2. **Riveted beam knees**

(*a*) Rivet diameter, d, is to be based on modulus as follows:—

Modulus—inches^3	d—inch
Below 7	$\frac{5}{8}$
7 – 18	$\frac{3}{4}$
Above 18	$\frac{7}{8}$

(*b*) The number of rivets, N, in each overlap is not to be less than $1 + \sqrt{\text{modulus}}$ to the nearest whole number with a minimum of four. Rivets are not to be spaced less than $3\frac{1}{2}$ diameters nor more than 7 diameters apart.

(*c*) The minimum length of overlap in inches is given by $3{\cdot}5\ \text{d} \times \text{N}$.

The depth of the knee below the bottom of the beam is not to be less than the depth of the beam.

3. **Welded beam knees**

(*a*) The length of overlap on beam or frame in inches is not to be less than $3{\cdot}3\ \sqrt{\text{modulus}} - 2{\cdot}0$ with a minimum of 6·5 inches.

Where the modulus does not exceed 36 inches^3 the length of a flanged knee may be 85% of that obtained from this formula with a minimum of 5·5 inches.

The depth of the knee below the bottom of the beam is not to be less than the depth of the beam.

(*b*) The area of weld in square inches is not to be less than

$1{\cdot}5\ \sqrt{\text{modulus}} - 3{\cdot}0$ when modulus < 21
and $0{\cdot}7\ \sqrt{\text{modulus}} + 0{\cdot}7$ when modulus ≥ 21

The area of weld is defined as the product of throat thickness and length of weld. The throat thickness is not to be less than that required by Notes 5 and 6, Table 52 G.

4. **Longitudinal Framing**

(*a*) *Frame brackets.* Where the deck is framed longitudinally the brackets connecting the side frames to the deck clear of transverses are to be in accordance with the above requirements based on the modulus of the frame, but the horizontal arm of the bracket is to be extended to a longitudinal.

(*b*) *End brackets of deck longitudinals.* Where deck longitudinals are cut at transverse bulkheads, the minimum sectional area of the bracket at the end of the longitudinal, and also the area of weld connection, are to be equal to the sectional area of the longitudinal.

The depth of the bracket below the longitudinal is to be at least equal to the depth of the longitudinal.

5. **Knees used as frame straps**

(*a*) The number of rivets in the lower frame is to be not less than $1 + \sqrt{\text{modulus}_{\text{LF}}}$ to the nearest whole number with a minimum of four. ($\text{Modulus}_{\text{LF}}$ is the modulus of the lower frame.)

(*b*) The number of rivets in the upper frame is not to be less than $\sqrt{\text{modulus}_{\text{UF}}}$ to the nearest whole number with a minimum of three for butted or overlapped frames. ($\text{Modulus}_{\text{UF}}$ is the modulus of the upper frame.)

(*c*) Where butts of frames are welded, the total number of rivets in the combined frame arm is not to be less than $1 + \sqrt{\text{modulus}_{\text{LF}}}$ to the nearest whole number with not less than two rivets in each of the upper and lower frames.

(*d*) In no case is the total of the rivets in the upper and lower frames to be less than $1 + \sqrt{\text{modulus}_{\text{B}}}$ where $\text{modulus}_{\text{B}}$ is the modulus of the beam.

(*e*) The riveting or welding of the arm to the beam, and the overlap on the beam, are to be as required by paragraphs (2) or (3) above. The modulus to be used is that of the beam or lower frame, whichever is greater.

(*f*) The welding of the knee to the upper or lower frame is to be in accordance with paragraph 3(*b*) using the modulus of the upper or lower frame as appropriate.

(*g*) The minimum length of overlap on the lower frame in inches is to be $3{\cdot}5\ \text{d} \times \text{N}$ for riveted knees or $3{\cdot}3\ \sqrt{\text{modulus}_{\text{LF}}} - 2{\cdot}0$ for welded knees, with a minimum of 6·5 inches.

(*h*) For butted or lapped frames the overlap on the 'tween deck frame is not to be less than $3{\cdot}5\ \text{d} \times \text{N}$ for riveted knees or $3{\cdot}3\ \sqrt{\text{modulus}_{\text{UF}}} - 2{\cdot}0$ for welded knees, with a minimum of 6·5 inches.

(*i*) Where the frames are butted the thickness of beam knee, if required to be flanged, is to be increased ·08 inch or, where $\text{modulus}_{\text{LF}}$ or $\text{modulus}_{\text{B}}$ (whichever is greater) does not exceed 36 inches^3, it is to be flanged.

TABLE 29

(SEE CONTINUATION)

DECK GIRDERS

NUMERAL	DEPTH OF END BRACKETS BELOW DECK	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS							
		Inches 10 × ·32	Inches 11 × ·34	Inches 12 × ·34	Inches 13 × ·34	Inches 14 × ·34	Inches 15 × ·36	Inches 16 × ·36	Inches 17 × ·36
		REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS. (see also NOTE 4)							
		·30	*·30*	*·35*	*·40*	*·40*	*·45*	*·45*	*·50*
		FACE AREA							
	Inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches
50	19	·8							
100	21	2·6	2·1	1·7					
200	24	5·2	4·5	3·9	3·3	2·8			
300	27	7·1	6·2	5·5	4·8	4·2	3·6	3·2	2·7
400	30	9·9	8·7	7·8	6·9	6·1	5·4	4·8	4·3
600	33		13·8	12·4	11·1	10·0	9·0	8·2	7·4
800	36			17·0	15·4	14·0	12·6	11·6	10·6
1000	38			21·7	19·7	17·9	16·3	15·0	13·8
1200	40				23·9	21·8	20·0	18·5	17·0
1400	42						23·7	22·0	20·2
1600	44							25·5	23·4
1800	46								26·6
2000	48								
2200									
2400									
2600									

For notes see page 123

TABLE 29

(SEE CONTINUATION)

DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS								DEPTH OF END BRACKETS BELOW DECK	NUMERAL
Inches 18 × ·36	Inches 19 × ·38	Inches 20 × ·38	Inches 21 × ·38	Inches 22 × ·38	Inches 23 × ·40	Inches 24 × ·40	Inches 25 × ·40		
REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4)									
·50	*·55*	*·60*	*·60*	*·65*	*·65*	*·70*	*·70*		
FACE AREA									
Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Square inches	Inches	
								19	50
								21	100
								24	200
2·3								27	300
3·8	3·3	2·8	2·5					30	400
6·8	6·0	5·4	5·0	4·5	3·9	3·5	3·1	33	600
9·8	8·9	8·1	7·5	6·9	6·2	5·7	5·2	36	800
12·8	11·7	10·8	10·1	9·3	8·6	7·9	7·4	38	1000
15·8	14·6	13·5	12·6	11·8	10·9	10·1	9·5	40	1200
18·8	17·4	16·2	15·2	14·2	13·2	12·3	11·6	42	1400
21·9	20·3	19·0	17·7	16·7	15·5	14·6	13·8	44	1600
24·9	23·2	21·7	20·3	19·1	17·9	16·8	15·9	46	1800
27·9	26·1	24·4	22·9	21·5	20·3	19·1	18·1	48	2000
		27·1	25·5	23·9	22·6	21·3	20·2		2200
				26·3	24·9	23·6	22·3		2400
							24·4		2600

For notes see page 123

TABLE 29

(SEE CONTINUATION)

DECK GIRDERS

NUMERAL	DEPTH OF END BRACKETS BELOW DECK	DEPTH OF WEB PLATE BELOW DECK AND MINIMUM THICKNESS										
		Inches 26×·40	Inches 27×·42	Inches 28×·42	Inches 29×·42	Inches 30×·42	Inches 31×·44	Inches 32×·44	Inches 33×·44	Inches 34×·44	Inches 35×·46	Inches 36×·46
		REDUCTION IN FACE AREA (SQUARE INCH) PER ·1 INCH INCREASE IN WEB THICKNESS (see also NOTE 4)										
		·75	*·80*	*·80*	*·85*	*·85*	*·90*	*·90*	*·95*	*·95*	*1·00*	*1·00*
		FACE AREA										
	Inches	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.	Sq. ins.
50	19											
100	21											
200	24											
300	27											
400	30											
600	33											
800	36	4·7	4·2	3·8	3·3							
1000	38	6·8	6·1	5·6	5·2	4·7	4·1	3·7	3·3			
1200	40	8·9	8·1	7·6	7·0	6·5	5·8	5·4	4·9	4·5	3·9	3·4
1400	42	10·9	10·1	9·5	8·8	8·3	7·5	7·1	6·5	6·0	5·4	4·9
1600	44	13·0	12·1	11·4	10·6	10·1	9·3	8·7	8·1	7·6	6·9	6·4
1800	46	15·0	14·0	13·3	12·5	11·8	11·0	10·4	9·8	9·2	8·4	7·9
2000	48	17·1	16·0	15·2	14·3	13·6	12·7	12·0	11·4	10·7	9·9	9·3
2200		19·2	18·0	17·1	16·2	15·4	14·4	13·7	13·0	12·3	11·5	10·8
2400		21·2	20·0	19·0	18·0	17·2	16·1	15·4	14·6	13·9	13·0	12·3
2600		23·3	22·0	20·9	19·9	18·9	17·9	17·0	16·2	15·4	14·6	13·8
2800			24·0	22·9	21·8	20·7	19·6	18·7	17·8	17·0	16·1	15·2
3000				24·8	23·6	22·5	21·3	20·4	19·5	18·6	17·7	16·7

For notes see page 123

NOTES.—TABLE 29

1. Longitudinal girders

The numeral for use in the Table is given by :

$$\frac{l^2 \times b \times h}{100}$$

where l = the span of the girder, in feet, from pillar to pillar, or from pillar to bulkhead less half the distance between the toe of the end bracket and the bulkhead.

b = the mean width of deck, in feet, supported by the girder.

h is to be measured as follows :

(*a*) For decks on which cargo is carried h is the mean height in feet from top of beam to top of beam of the 'tween decks next above the girder.

(*b*) For decks under accommodation spaces h is 4 feet. (*See also* note 1 (*e*).)

(*c*) For weather decks, except in the forward ·12L, h is 4 feet if the draught does not exceed ·7D and 5 feet if the draught is ·85D or greater, with intermediate values in proportion, D being measured to the uppermost continuous deck. (*See also* note 1 (*e*).)

(*d*) Weather decks. For the forward ·075L h is to be 6 feet, irrespective of draught. Between ·075L and ·12L from forward, h is to be 5 feet, irrespective of draught.

(*e*) For decks above the uppermost continuous deck h, as given in (*b*) and (*c*), may be successively reduced by one foot for each deck to a minimum of 1·5 feet.

(*f*) Where decks support a hanging cargo, such as chilled meat, in addition to deck loads, the value of h is to be increased by 2·5 feet for one tier, 5 feet for two tiers and 7·5 feet for three tiers of quarters.

2. Strong hatch side coamings and end beams in 'tween decks

(*a*) Side coamings.

The numeral for use in the Table is given by :

$$\frac{1{\cdot}1 \times l^2 \times b \times h}{100}$$

where l = the length of the hatchway in feet.

b = the mean breadth in feet of deck, including hatchway, supported by the coaming.

h = the mean height in feet of 'tween decks as in note 1.

(*b*) Hatch end beams.

For strong hatch end beams which are supported at the centre line and carry the hatch side coamings only, the numeral for use in the Table is given by :

$$\cdot 75\ B \times \frac{l \times b \times h}{100}$$

where B = the span of the hatch end beam, in feet, measured from the centre line to the ship's side less half the distance between the toe of the bracket and the ship's side.

l, b and h are measured as in note 2 (*a*).

Where the hatch end beam supports the hatch side coaming and, in addition, an adjacent longitudinal girder in line, the numeral is given by :

$$\cdot 75\ B \left(\frac{l_1 \times b_1 \times h}{100} + \frac{l_2 \times b_2 \times h}{100} \right)$$

where l_1, b_1, and h are measured as in note 2 (*a*) and l_2 and b_2 are measured as in note 1.

(*c*) The depth of strong hatch end beams derived from the Table is to be maintained for the full breadth of the ship.

(*d*) Strong hatch side coamings and end beams supporting deck longitudinals in association with transverses will be specially considered.

3. Transverses supporting deck longitudinals

The numeral for use in the Table is given by :

$$\frac{l^2 \times b \times h}{100}$$

where l = the span, in feet, of the transverse measured from pillar to pillar or from pillar to ship's side less half the distance between the toe of the bracket and the ship's side.

b is the length of deck in feet supported by the transverses.

h is measured as in note 1.

In single deck ships the depth of the transverses is to be increased by 15 per cent.

4. The sectional area of girder flanges derived from the Table may take the form of rolled sections, or flanged girder plates, with rider plates where necessary, the depth of the girder being measured to the bottom of the web. Where the depth of beam or longitudinal notches exceeds 50 per cent of the depth of the girder or 12 inches, whichever is less, the face area is to be suitably increased. The width of the flange is not to exceed the depth of the girder.

5. For end connections and constructional details *see* D 1505 to D 1515. For spacing of girders and transverses in the forward ·075L *see* D 1501.

6. Timber Deck Cargoes. Where timber load lines are to be assigned, h in the foregoing formulæ for weather decks is to be taken at 5 ft. where the beam B does not exceed 50 ft., and 6 ft. where the beam is 60 ft. or over, with intermediate values in proportion. In single deck ships the depth of the transverses supporting deck longitudinals (note 3) is to be increased by 30 per cent.

DECK RUNNERS

NUMERAL	DOUBLE ANGLES		SINGLE ANGLE OR BULB ANGLE
	Inches		Inches
5	3 × 2½ × ·26	ANGLES	3½ × 3 × ·36
10	3½ × 3 × ·30		5 × 3 × ·31
15	4 × 3 × ·32		5 × 3 × ·44
20	4 × 3 × ·40	BULB ANGLES	5 × 3 × ·32
25	4 × 3 × ·45		5 × 3 × ·40
30	5 × 3 × ·36		5½ × 3 × ·34
35	5 × 3 × ·40		6 × 3 × ·32
40	5 × 3 × ·46		6 × 3 × ·38
45	6 × 3 × ·36		6 × 3 × ·48
50	6 × 3 × ·40		7 × 3 × ·36
55	6 × 3 × ·44		7 × 3 × ·40

NOTES.—TABLE 30

1. The numeral is to be determined in accordance with Table 29, note 1.
2. The runners are to be fitted with the deep flange vertical.

TABLE 31

(SEE CONTINUATION)

PILLARS

NUMERAL	LENGTH AND FORM OF PILLAR											
	Feet 8						Feet 12					
	TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID		
	OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS	
	Inches	Inches	Inches	Inches	No.	Inches	Inches	Inches	Inches	Inches	No.	Inches
4	$2\frac{1}{2}\times\cdot34$			$2\frac{3}{8}$	2	$\frac{7}{8}$	$3\frac{1}{2}\times\cdot34$			$2\frac{7}{8}$	2	$\frac{7}{8}$
6	$3\frac{1}{2}\times\cdot32$			$2\frac{5}{8}$	2	$\frac{7}{8}$	$4\times\cdot36$			$3\frac{1}{8}$	2	$\frac{7}{8}$
8	$4\times\cdot34$			$2\frac{7}{8}$	2	$\frac{7}{8}$	$4\frac{1}{2}\times\cdot36$			$3\frac{3}{8}$	2	$\frac{7}{8}$
10	$4\frac{1}{2}\times\cdot36$			$3\frac{1}{8}$	2	$\frac{7}{8}$	$5\times\cdot38$	$6\times3\times3\times\cdot36$		$3\frac{5}{8}$	3	$\frac{7}{8}$
15	$5\frac{1}{2}\times\cdot36$	$6\times3\times3\times\cdot36$		$3\frac{1}{2}$	3	$\frac{7}{8}$	$6\times\cdot40$	$6\times3\times3\times\cdot44$		$4\frac{1}{4}$	3	$\frac{7}{8}$
20	$6\times\cdot40$	$6\times3\times3\times\cdot44$		4	3	1	$7\times\cdot40$	$6\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot36$		5	4	1
30	$8\times\cdot40$	$7\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot38$		$4\frac{1}{2}$	4	1	$8\frac{1}{2}\times\cdot42$	$8\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot38$		$5\frac{1}{2}$	5	1
40	$9\times\cdot44$	$8\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$		5	5	1	$10\times\cdot44$	$9\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$		6	6	1
50	$10\times\cdot50$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$		$5\frac{1}{2}$	6	1	$11\times\cdot48$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot60$		$6\frac{1}{2}$	6	1
60	$11\times\cdot54$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot60$		6	6	1	$11\times\cdot56$	$9\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$	$10\times\cdot40$			
70	$13\times\cdot52$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot44$	$10\times\cdot42$				$13\times\cdot54$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$	$11\times\cdot46$			
85	$15\times\cdot54$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot48$	$12\times\cdot50$				$15\times\cdot55$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot56$	$12\times\cdot50$			
100	$17\times\cdot56$	$10\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$	$12\times\cdot60$				$16\times\cdot62$	$12\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot46$	$13\times\cdot60$			
120	$18\times\cdot60$	$12\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot48$	$13\times\cdot70$				$18\times\cdot65$	$12\times3\frac{1}{2}\times3\frac{1}{2}\times\cdot50$	$13\times\cdot74$			
140	$18\times\cdot66$						$20\times\cdot66$					
160	$20\times\cdot66$						$22\times\cdot66$					
180	$22\times\cdot68$						$24\times\cdot70$					
200	$24\times\cdot72$						$26\times\cdot74$					
220	$26\times\cdot74$						$26\times\cdot78$					
240	$26\times\cdot78$						$28\times\cdot80$					
260	$28\times\cdot80$						$30\times\cdot80$					

For notes see page 128

TABLE 31

(SEE CONTINUATION)

LENGTH AND FORM OF PILLAR												NUMERAL
Feet 16						Feet 20						
TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			
OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		
Inches	Inches	Inches	Inches	No.	Inches	Inches	Inches	Inches	Inches	No.	Inches	
4 × ·36			$3\frac{1}{4}$	2	$\frac{7}{8}$	$4\frac{1}{2}$×·38			$3\frac{7}{8}$	3	$\frac{7}{8}$	4
5 × ·36			$3\frac{3}{4}$	2	$\frac{7}{8}$	$5\frac{1}{2}$×·36			$4\frac{1}{4}$	3	$\frac{7}{8}$	6
$5\frac{1}{2}$×·38			4	3	$\frac{7}{8}$	6 × ·40			$4\frac{5}{8}$	3	$\frac{7}{8}$	8
6 × ·38	6 × 3 × 3 ×·44		$4\frac{1}{2}$	3	$\frac{7}{8}$	$6\frac{1}{2}$×·40	7×$3\frac{1}{2}$×$3\frac{1}{2}$×·42		$5\frac{1}{4}$	4	$\frac{7}{8}$	10
7 × ·40	6×$3\frac{1}{2}$×$3\frac{1}{2}$×·36		$5\frac{1}{4}$	4	$\frac{7}{8}$	8 × ·38	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·38		6	4	1	15
8 × ·40	7×$3\frac{1}{2}$×$3\frac{1}{2}$×·38		6	5	1	$8\frac{1}{2}$×·42	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·48					20
9 × ·44	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·48					10 × ·44	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·50					30
10 × ·48	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·50					11 × ·48	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·38	10×·40				40
11 × ·50	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	10×·40				12 × ·52	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·48	11×·44				50
12 × ·55	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·50	11×·46				13 × ·54	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·50				60
14 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·52				14 × ·58	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·60				70
15 × ·58	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·60				16 × ·60	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·48	13×·72				85
17 × ·57	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·50	13×·70				17 × ·66						100
19 × ·64						19 × ·68						120
20 × ·70						22 × ·68						140
22 × ·72						23 × ·72						160
24 × ·72						25 × ·74						180
26 × ·74						27 × ·78						200
27 × ·79						28 × ·82						220
29 × ·80						31 × ·82						240
31 × ·82												260

For notes see page 128

TABLE 31
(CONCLUDED)

PILLARS

NUMERAL	LENGTH AND FORM OF PILLAR											
	Feet 24						Feet 28					
	TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID			TUBULAR	DOUBLE CHANNELS AND FACE PLATES		SOLID		
	OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS		OUTSIDE DIAMETER	CHANNELS	FACE PLATES	DIAMETER	RIVETS IN ENDS	
	Inches	Inches	Inches	Inches	No.	Inches	Inches	Inches	Inches	Inches	No.	Inches
4				$4\frac{3}{8}$	3	$\frac{7}{8}$				$4\frac{7}{8}$	4	$\frac{7}{8}$
6				$4\frac{3}{4}$	3	$\frac{7}{8}$				$5\frac{1}{2}$	4	$\frac{7}{8}$
8	7 × ·38			$5\frac{1}{2}$	4	$\frac{7}{8}$	8 × ·38			6	4	1
10	$7\frac{1}{2}$×·38	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·46		6	4	1	$8\frac{1}{2}$×·40	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·52				
15	$8\frac{1}{2}$×·40	8×$3\frac{1}{2}$×$3\frac{1}{2}$×·50					9 × ·44	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·52				
20	9 × ·44	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·52					10 × ·42	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·60				
30	10 × ·48	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·60					11 × ·48	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·44	10×·42			
40	11 × ·52	9×$3\frac{1}{2}$×$3\frac{1}{2}$×·48	10×·42				12 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·50	11×·46			
50	13 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·48	12×·50				14 × ·52	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·56			
60	14 × ·56	10×$3\frac{1}{2}$×$3\frac{1}{2}$×·56	12×·60				15 × ·56	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·64			
70	15 × ·58	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·70				16 × ·60	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·50	13×·74			
85	17 × ·62	12×$3\frac{1}{2}$×$3\frac{1}{2}$×·46	13×·74				18 × ·62					
100	19 × ·64						19 × ·66					
120	20 × ·70						21 × ·70					
140	23 × ·70											
160	25 × ·72											
180	26 × ·80											
200	29 × ·80											
220												
240												
260												

NOTES.—TABLE 31

1. The numeral for use in the Table is to be the sum of the numerals representing the separate loads which may be transmitted to the pillar, namely :

(*a*) The numeral in respect of that proportion of the deck load, supported by a girder, hatch end beam or deck transverse, which is borne by the pillar.

(*b*) The numeral of the directly superimposed pillar, if any.

2. The numeral is to be determined by :

$$\frac{s \times b \times h}{100}$$

where s = the distance in feet between the centres of the two adjacent spans of girder supported by the pillar.

b = the mean width of deck, including hatchway if necessary, supported by the girders over the distances.

h is to be measured as defined in Table 29, note 1.

3. Pillars equivalent to those shown in the Tables, of riveted or welded construction, will be accepted.

When hollow square pillars are fitted, the thickness is to be the same as that of the tubular pillar required and the side is to be 80 per cent of the diameter of the tubular pillar.

4. When solid pillars are fitted in pairs to take shifting boards, their diameter is to be 75 per cent of that required by the Table.

5. For end connections and constructional details *see* D 1516 to D 1524.

6. Timber Deck Cargoes. Where timber load lines are to be assigned, h is to be measured as defined in Table 29, note 6.

BULKHEAD PLATING

Stiffeners spaced 30 inches apart on watertight bulkheads and 24 inches apart on collision, deep tank, peak tank and oil fuel bunker bulkheads

DEPTH (*See* NOTE 1)	THICKNESS	DEPTH (*See* NOTE 1)	THICKNESS
Feet	Inches	Feet	Inches
8	·26	36	·40
12	·28	40	·42
16	·30	44	·44
20	·32	48	·46
24	·34	52	·48
28	·36	56	·50
32	·38	60	·52

NOTES.—TABLE 32

1. Depth is to be measured as follows :—

(*a*) For watertight bulkheads (D 16). From the lower edge of the plate to the top of the bulkhead at the centre line.

(*b*) For bulkheads of tanks (D 19 and D 20). From the lower edge of the plate to the top of the tank or to a point midway between the half-depth of the tank and the top of the overflow, whichever distance is greater.

2. Correction for spacing of stiffeners. Where the spacing of stiffeners differs from that given in the Table the thickness of the plating is to be modified at the rate of 2 per cent for every inch of difference except that where the spacing on tank or oil bunker bulkheads exceeds 24 inches the thickness is to be increased at the rate of 3 per cent per inch difference of spacing.

3. Additions to thickness, as corrected by note 2, are to be made as follows :—

(*a*) To the lowest strake of hold and tank bulkheads ... ... ·04 inch.

(*b*) To the lowest strake of stokehold bulkheads in coal burning ships ... ... ·10 inch.

(*c*) Plates in limbers and at the bottom of peak bulkheads ... ... ·10 inch.

(*d*) In way of the stern tube, plating to be increased substantially or doubled.

4. The plating of deep tank, peak tank and oil fuel bunker bulkheads in ships exceeding 150 feet in length is not to be less than ·30 inch after correction.

TABLE 33

(SEE CONTINUATION)

BULKHEAD STIFFENE

Spaced 24 inches apart on collision bulkhe

LENGTH OF STIFFENER	HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
	0	2	4	6	8	10	12
Feet	INCHES — *Modulus—Inches*^{3}						
8	4 × 3 × ·30 *1·65*	4 × 3 × ·38 *2·10*	4 × 3 × ·43 *2·35*	5 × 3 × ·32 *2·70*	5 × 3 × ·39 *3·25*	5 × 3 × ·44 *3·65*	6 × 3 × ·34 *4·10*
9	4 × 3 × ·40 *2·20*	5 × 3 × ·32 *2·70*	5 × 3 × ·36 *3·00*	5 × 3 × ·44 *3·65*	6 × 3 × ·36 *4·30*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*
10	5 × 3 × ·34 *2·85*	5 × 3 × ·42 *3·50*	6 × 3 × ·34 *4·10*	6 × 3 × ·38 *4·55*	5½ × 3 × ·34 *5·60*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*
11	5 × 3 × ·44 *3·65*	6 × 3 × ·36 *4·30*	5½ × 3 × ·34 *5·60*	5½ × 3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*	6 × 3 × ·47 *8·60*
12	6 × 3 × ·38 *4·55*	5½ × 3 × ·36 *5·80*	6 × 3 × ·35 *6·95*	6 × 3 × ·38 *7·35*	6 × 3 × ·47 *8·60*	7 × 3 × ·37 *10·10*	7 × 3 × ·39 *10·45*
13	5½ × 3 × ·37 *5·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*
14	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*
15	6 × 3 × ·45 *8·35*	7 × 3 × ·37 *10·10*	7 × 3 × ·48 *12·05*	7 × 3 × ·51 *12·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*
16	7 × 3 × ·37 *10·10*	7 × 3 × ·48 *12·05*	8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*	8 × 3 × ·51 *16·85*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*
17	7 × 3 × ·48 *12·05*	8 × 3 × ·39 *14·10*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*
18	8 × 3 × ·39 *14·10*	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*
19	8 × 3 × ·49 *16·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*
20	9 × 3½ × ·41 *19·15*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·53 *28·45*	10 × 3½ × ·55 *29·15*	*30·90*	11 × 3½ × ·53 *35·00*
21	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·61 *38·20*
22	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
23	10 × 3½ × ·50 *27·40*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 4 × 4 × · *45·40*
24	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × · *48·60*
25	11 × 3½ × ·51 *34·20*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × · *53·75*
26	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·54 *48·60*	12 × 4 × 4 × ·64 *52·60*	*55·50*	
27	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·50 *47·00*	*54·50*	*58·60*		

BULB ANGLES — ANGLES

For notes see page 137

Section moduli above

nd 30 inches apart on other watertight bulkheads

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET							LENGTH OF STIFFENER	
14	16	18	20	22	24	26		
INCHES — *Modulus—Inches³*							Feet	
6 × 3 × ·36 *4·30*	5½ × 3 × ·28 *4·95*	5½ × 3 × ·34 *5·60*	5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·39 *7·50*	BULB ANGLES	8
5½ × 3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·36 *7·10*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	6 × 3 × ·50 *9·00*	7 × 3 × ·37 *10·10*		9
6 × 3 × ·38 *7·35*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*		10
7 × 3 × ·36 *9·95*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·42 *14·75*		11
7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·51 *16·85*	9 × 3½ × ·38 *18·40*		12
8 × 3 × ·39 *14·10*	8 × 3 × ·42 *14·75*	8 × 3 × ·53 *17·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·51 *21·90*		13
8 × 3 × ·49 *16·35*	9 × 3½ × ·38 *18·40*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·49 *21·35*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*		14
9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·52 *28·10*	*30·90*		15
9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*		16
10 × 3½ × ·42 *24·80*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*		17
30·90	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·54 *43·05*		18
11 × 3½ × ·53 *35·00*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·56 *44·00*	12×4×4×·48 *46·20*	CHANNELS	19
11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·52 *47·80*	12×4×4×·62 *51·80*		20
12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·67 *53·75*	*57·50*		21
12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*59·70*	15×4×4×·48 *64·60*		22
12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*			23
12 × 4 × 4 × ·64 *52·60*	*57·50*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*					24
								25
								26
								27

given to nearest ·05

For notes see page 137

TABLE 33 (CONCLUDED) BULKHEAD STIFFENERS—BRACKETED

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
		28	30	32	34	36	38	40
Feet		INCHES — *Modulus—Inches³*						
8	BULB ANGLES	6 × 3 × ·45 *8·35*	6 × 3 × ·47 *8·60*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·38 *10·25*	7 × 3 × ·40 *10·60*	7 × 3 × ·48 *12·05*
9	BULB ANGLES	7 × 3 × ·40 *10·60*	7 × 3 × ·47 *11·85*	7 × 3 × ·48 *12·05*	7 × 3 × ·49 *12·25*	8 × 3 × ·38 *13·85*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*
10	BULB ANGLES	7 × 3 × ·51 *12·60*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·48 *16·10*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·41 *19·15*
11	BULB ANGLES	8 × 3 × ·49 *16·35*	8 × 3 × ·51 *16·85*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·44 *19·90*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*
12	BULB ANGLES	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·50 *27·40*
13	BULB ANGLES	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*
14	BULB ANGLES	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*
15	BULB ANGLES	11 × 3½ × ·44 *31·55*	11 × 3½ × ·51 *34·20*	11 × 3½ × ·54 *35·40*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
16	BULB ANGLES	11 × 3½ × ·60 *37·80*	11 × 3½ × ·61 *38·20*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12×4×4×·48 *46·20*
17	BULB ANGLES	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·52 *47·80*	12×4×4×·62 *51·80*
18	BULB ANGLES	12 × 3½ × ·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	12 × 4 × 4 × ·67 *53·75*	*57·50*
19	CHANNELS	12×4×4×·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15×4×4×·48 *64·60*
20	CHANNELS	12×4×4×·67 *53·75*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*		
21	CHANNELS	*59·70*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*				
22	CHANNELS	15×4×4×·50 *65·85*						
23	CHANNELS							
24	CHANNELS							
25	CHANNELS							
26	CHANNELS							
27	CHANNELS							

For notes see page 137

Section moduli are given to nearest ·05

TABLE 34

(SEE CONTINUATION)

BULKHEAD STIFFENER

Spaced 24 inches apart on collision bulkhe

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
		0	2	4	6	8	10	12
Feet		← INCHES *Modulus—Inches³* →						
8	ANGLES	*4 × 3 × ·43 *2·35*	5 × 3 × ·36 *3·00*	5 × 3 × ·46 *3·80*	6 × 3 × ·38 *4·55*	5½×3 × ·36 *5·80*	5½×3 × ·38 *6·05*	6 × 3 × ·35 *6·95*
9	ANGLES	*5 × 3 × ·42 *3·50*	5 × 3 × ·47 *3·90*	5½×3 × ·36 *5·80*	5½×3 × ·38 *6·05*	6 × 3 × ·35 *6·95*	6 × 3 × ·39 *7·50*	6 × 3 × ·46 *8·45*
10	ANGLES	*6 × 3 × ·38 *4·55*	5½×3 × ·37 *5·95*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*
11	BULB ANGLES	5½×3 × ·38 *6·05*	6 × 3 × ·38 *7·35*	6 × 3 × ·46 *8·45*	7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*
12	BULB ANGLES	6 × 3 × ·39 *7·50*	6 × 3 × ·50 *9·00*	7 × 3 × ·39 *10·45*	7 × 3 × ·48 *12·05*	7 × 3 × ·54 *13·15*	8 × 3 × ·42 *14·75*	8 × 3 × ·51 *16·85*
13	BULB ANGLES	6 × 3 × ·45 *8·35*	7 × 3 × ·40 *10·60*	7 × 3 × ·51 *12·60*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	9 × 3½×·41 *19·15*	9 × 3½×·44 *19·90*
14	BULB ANGLES	7 × 3 × ·41 *10·80*	7 × 3 × ·52 *12·80*	8 × 3 × ·49 *16·35*	8 × 3 × ·53 *17·35*	9 × 3½×·43 *19·65*	9 × 3½×·51 *21·90*	9 × 3½×·54 *22·70*
15	BULB ANGLES	7 × 3 × ·52 *12·80*	8 × 3 × ·45 *15·45*	9 × 3½×·41 *19·15*	9 × 3½×·45 *20·20*	9 × 3½×·52 *22·20*	10 × 3½×·42 *24·80*	10 × 3½×·50 *27·40*
16	BULB ANGLES	8 × 3 × ·49 *16·35*	9 × 3½×·41 *19·15*	9 × 3½×·51 *21·90*	10 × 3½×·41 *24·50*	10 × 3½×·45 *25·80*	10 × 3½×·55 *29·15*	11 × 3½×·44 *31·55*
17	BULB ANGLES	9 × 3½×·43 *19·65*	9 × 3½×·51 *21·90*	10 × 3½×·42 *24·80*	10 × 3½×·52 *28·10*	*30·90*	11 × 3½×·46 *32·30*	11 × 3½×·56 *36·20*
18	BULB ANGLES	9 × 3½×·51 *21·90*	10 × 3½×·44 *25·45*	10 × 3½×·55 *29·15*	11 × 3½×·44 *31·55*	11 × 3½×·55 *35·80*	11 × 3½×·61 *38·20*	12 × 3½×·51 *41·65*
19	BULB ANGLES	10 × 3½×·42 *24·80*	10 × 3½×·53 *28·45*	11 × 3½×·45 *31·95*	11 × 3½×·58 *37·00*	11 × 3½×·63 *39·00*	12 × 3½×·51 *41·65*	12 × 4 × 4 × ·4 *46·20*
20	BULB ANGLES	*30·90*	11 × 3½×·46 *32·30*	11 × 3½×·60 *37·80*	12 × 3½×·51 *41·65*	12 × 3½×·52 *42·10*	12 × 4 × 4 × ·48 *46·20*	13 × 4 × 4 × ·6 *51·80*
21	BULB ANGLES	11 × 3½×·46 *32·30*	11 × 3½×·60 *37·80*	12 × 3½×·51 *41·65*	12 × 3½×·56 *44·00*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	*57·50*
22	BULB ANGLES	11 × 3½×·60 *37·80*	12 × 3½×·51 *41·65*	12 × 3½×·56 *44·00*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	*57·50*	15 × 4 × 4 × ·4 *63·35*
23	BULB ANGLES	12 × 3½×·51 *41·65*	12 × 3½×·58 *44·95*	12 × 4 × 4 × ·54 *48·60*	12 × 4 × 4 × ·67 *53·75*	*57·50*	15 × 4 × 4 × ·46 *63·35*	
24	BULB ANGLES	12 × 3½×·58 *44·95*	12 × 4 × 4 × ·56 *49·40*	*54·50*	*59·70*	15 × 4 × 4 × ·48 *64·60*		
25	CHANNELS	12×4×4×·54 *48·60*	*55·50*	*60·80*	15 × 4 × 4 × ·50 *65·85*			
26	CHANNELS	*54·50*	15 × 4 × 4 × ·44 *62·15*	15 × 4 × 4 × ·53 *67·65*				
27	CHANNELS	*60·80*	15 × 4 × 4 × ·55 *68·85*					

The ends of upper 'tween deck stiffeners marked * may be riveted to the boundary angle only, without lug attachment

Section moduli above a

TABLE 34

(SEE CONTINUATION)

d 30 inches apart on other watertight bulkheads

HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET							LENGTH OF STIFFENER
14	16	18	20	22	24	26	
INCHES — *Modulus—Inches³*							Feet
6 × 3 × ·40 *7·65*	6 × 3 × ·47 *8·35*	6 × 3 × ·48 *8·75*	7 × 3 × ·37 *10·10*	7 × 3 × ·39 *10·45*	7 × 3 × ·41 *10·80*	7 × 3 × ·48 *12·05*	8
7 × 3 × ·37 *10·10*	7 × 3 × ·40 *10·60*	7 × 3 × ·43 *11·15*	7 × 3 × ·49 *12·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	9
7 × 3 × ·48 *12·05*	7 × 3 × ·52 *12·80*	8 × 3 × ·41 *14·55*	8 × 3 × ·49 *16·35*	8 × 3 × ·52 *17·10*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	10
8 × 3 × ·42 *14·75*	8 × 3 × ·49 *16·35*	8 × 3 × ·53 *17·35*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·41 *24·50*	11
9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·46 *26·10*	10 × 3½ × ·50 *27·40*	12
9 × 3½ × ·51 *21·90*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·44 *25·45*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·53 *35·00*	13
10 × 3½ × ·44 *25·45*	10 × 3½ × ·52 *28·10*	*30·90*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	14
30·90	11 × 3½ × ·45 *31·95*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·56 *44·00*	15
11 × 3½ × ·45 *31·95*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12×4×4×·62 *51·80*	16
11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	17
12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*59·70*	15×4×4×·48 *64·60*	18
12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	*57·50*	*59·70*	15 × 4 × 4 × ·46 *63·35*			19
12 × 4 × 4 × ·67 *53·75*	*57·50*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·53 *67·65*				20
59·70	15 × 4 × 4 × ·50 *65·85*						21
							22
							23
							24
							25
							26
							27

BULB ANGLES

CHANNELS

For notes see page 137

given to nearest ·05

TABLE 34
(CONCLUDED)

BULKHEAD STIFFENERS—LUGGED

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads

LENGTH OF STIFFENER		HEIGHT OF TOP OF BULKHEAD AT MIDDLE LINE ABOVE TOP OF STIFFENER — FEET						
		28	30	32	34	36	38	40
Feet		INCHES — *Modulus—Inches³*						
8	BULB ANGLES	7 × 3 × ·52 *12·80*	8 × 3 × ·39 *14·10*	8 × 3 × ·41 *14·55*	8 × 3 × ·43 *15·00*	8 × 3 × ·51 *16·85*	8 × 3 × ·52 *17·10*	8 × 3 × ·53 *17·35*
9	BULB ANGLES	8 × 3 × ·52 *17·10*	8 × 3 × ·53 *17·35*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·43 *19·65*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*
10	BULB ANGLES	9 × 3½ × ·45 *20·20*	9 × 3½ × ·51 *21·90*	9 × 3½ × ·52 *22·20*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*
11	BULB ANGLES	10 × 3½ × ·42 *24·80*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·53 *28·45*	*30·90*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·53 *35·00*
12	BULB ANGLES	*30·90*	11 × 3½ × ·45 *31·95*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	11 × 3½ × ·63 *39·00*	12 × 3½ × ·51 *41·65*
13	BULB ANGLES	11 × 3½ × ·55 *35·80*	11 × 3½ × ·60 *37·80*	12 × 3½ × ·46 *39·45*	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·54 *43·05*	12×4×4×·48 *46·20*
14	BULB ANGLES	12 × 3½ × ·51 *41·65*	12 × 3½ × ·52 *42·10*	12 × 3½ × ·58 *44·95*	12 × 4 × 4 × ·48 *46·20*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	*57·50*
15	CHANNELS	12×4×4×·48 *46·20*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·62 *51·80*	12 × 4 × 4 × ·64 *52·60*	*57·50*	*58·60*	15×4×4×·46 *63·35*
16	CHANNELS	12×4×4×·64 *52·60*	*57·50*	*58·60*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·48 *64·60*	15 × 4 × 4 × ·50 *65·85*	
17	CHANNELS	*59·70*	15 × 4 × 4 × ·46 *63·35*	15 × 4 × 4 × ·50 *65·85*				
18	CHANNELS	15×4×4×·53 *67·65*						
19	CHANNELS							
20	CHANNELS							
21	CHANNELS							
22	CHANNELS							
23	CHANNELS							
24	CHANNELS							
25	CHANNELS							
26	CHANNELS							
27	CHANNELS							

For notes see page 137

Section moduli above are given to nearest ·05

TABLE 35

BULKHEAD STIFFENERS in TUGS

Spaced 24 inches apart on collision bulkheads and 30 inches apart on other watertight bulkheads

LENGTH OF STIFFENER		STIFFENERS BRACKETED AT ENDS	STIFFENERS WITHOUT BRACKETS OR LUGS AT ENDS
Feet		INCHES *Modulus—Inches³*	INCHES *Modulus—Inches³*
7	ANGLES ↑	—	$3\frac{1}{2}\times2\frac{1}{2}\times\cdot30$ *1·30*
8		$3\times2\frac{1}{2}\times\cdot28$ *·90*	$4\times3\times\cdot30$ *1·65*
9		$3\times2\frac{1}{2}\times\cdot30$ *1·00*	$4\times3\times\cdot34$ *1·90*
10		$3\frac{1}{2}\times2\frac{1}{2}\times\cdot32$ *1·40*	$4\times3\times\cdot43$ *2·35*
11		$4\times3\times\cdot32$ *1·80*	$5\times3\times\cdot34$ *2·85*
12		$4\times3\times\cdot40$ *2·20*	$5\times3\times\cdot42$ *3·50*
13		$5\times3\times\cdot32$ *2·70*	$6\times3\times\cdot36$ *4·30*
14		$5\times3\times\cdot42$ *3·50*	$6\times3\times\cdot42$ *5·00*
15		$6\times3\times\cdot36$ *4·30*	$6\times3\times\cdot49$ *5·75*
16	↓	$6\times3\times\cdot42$ *5·00*	—

TABLE 36

END ATTACHMENTS for STIFFENERS

TYPE AND DEPTH OF STIFFENER		BRACKET ATTACHMENTS				LUG ATTACHMENTS	
		Thickness of bracket	Width of flange	Number and size of rivets in each arm of bracket	Area of weld	Number and size of rivets in lugs	Area of weld
		Inches	Inches		Sq. inches		Sq. inches
Angles		·34	—	3 of $\frac{3}{4}$ Ins. Dia.	1·5	2 of $\frac{3}{4}$ Ins. Dia.	1·0
Bulb angles 6 inches & under		·36	—	3 „ $\frac{3}{4}$ „ „	1·5	2 „ $\frac{3}{4}$ „ „	1·0
Bulb angles 7 inches		·40	—	4 „ $\frac{3}{4}$ „ „	2·0	3 „ $\frac{3}{4}$ „ „	1·5
„ „ 8 „		·42	—	5 „ $\frac{3}{4}$ „ „	2·5	3 „ $\frac{3}{4}$ „ „	1·5
„ „ 9 „	FLANGED ↑	·34	$2\frac{1}{4}$	6 „ $\frac{3}{4}$ „ „	3·0	4 „ $\frac{3}{4}$ „ „	2·0
„ „ 10 „		·36	$2\frac{1}{2}$	7 „ $\frac{3}{4}$ „ „	3·5	4 „ $\frac{3}{4}$ „ „	2·0
„ „ 11 „		·38	$2\frac{3}{4}$	7 „ $\frac{7}{8}$ „ „	4·75	4 „ $\frac{7}{8}$ „ „	2·75
„ „ 12 „		·40	3	8 „ $\frac{7}{8}$ „ „	5·5	5 „ $\frac{7}{8}$ „ „	3·5
Channels $12\times3\frac{1}{2}\times3\frac{1}{2}$ inches		·40	3	9 „ $\frac{7}{8}$ „ „	6·25	6 „ $\frac{7}{8}$ „ „	4·0
„ $12\times4\times4$ inches		·40	3	10 „ $\frac{7}{8}$ „ „	7·0	7 „ $\frac{7}{8}$ „ „	4·75
„ $15\times4\times4$ inches	↓	·44	$3\frac{1}{2}$	13 „ $\frac{7}{8}$ „ „	9·0	8 „ $\frac{7}{8}$ „ „	5·5

NOTES.—TABLES 33, 34, 35 & 36

1. Length of stiffeners is to be measured over the full distance between the top and bottom boundaries of the bulkhead.

2. Correction for spacing.—If the spacing of the stiffeners differs from the Table spacing the modulus is to be modified in direct proportion.

3. Welded construction.—When the bulkhead plating, boundaries, stiffeners and end brackets are welded, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

4. Area of weld is the product of the throat thickness and the length of the weld. The throat thickness is not to be less than that required by Notes 5 & 6, Table 52 G.

5. Particulars of sections and moduli are given in Table 56.

TABLE 37

TUNNEL PLATING

Stiffeners spaced 36 inches apart

DEPTH (*See* NOTE 1)	THICKNESS		DEPTH (*See* NOTE 1)	THICKNESS	
	FLAT SIDE PLATING	CURVED TOP PLATING		FLAT SIDE PLATING	CURVED TOP PLATING
Feet	Inches	Inches	Feet	Inches	Inches
8	·29	·26	36	·45	·40
12	·31	·28	40	·47	·42
16	·33	·30	44	·49	·44
20	·35	·32	48	·51	·46
24	·38	·34	52	·54	·48
28	·40	·36	56	·56	·50
32	·42	·38	60	·58	·52

NOTES.—TABLE 37

1. Depth is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the lower edge of the plate.

2. Correction for spacing of stiffeners. When the spacing differs from 36 inches the thickness is to be modified at the rate of 2 per cent for every inch of difference.

3. For additions under hatchways *see* D 1702 to D 1703.

For tunnels in deep tanks *see* D 1910 and D 2014.

TUNNEL STIFFENERS

Spaced 36 inches apart

DEPTH (*See* NOTE 1)	LENGTH FROM BASE OF TUNNEL TO TOP OF FLAT SIDE					
	Feet 3	Feet 4	Feet 5	Feet 6	Feet 7	Feet 8
Feet	INCHES *Modulus—Inches*³					
12	3 × 2½ × ·24 *·80*	3½ × 3 × ·34 *1·45*	4 × 3 × ·38 *2·10*	5 × 3 × ·34 *2·85*	5 × 3 × ·44 *3·65*	5½ × 3 × ·35 *5·70*
16	3 × 2½ × ·29 *·95*	4 × 3 × ·30 *1·65*	5 × 3 × ·32 *2·70*	5 × 3 × ·44 *3·65*	5½ × 3 × ·35 *5·70*	6 × 3 × ·35 *6·95*
20	3½ × 2½ × ·26 *1·15*	4 × 3 × ·38 *2·10*	5 × 3 × ·42 *3·50*	6 × 3 × ·38 *4·55*	6 × 3 × ·35 *6·95*	6 × 3 × ·45 *8·35*
24	4 × 3 × ·28 *1·55*	5 × 3 × ·32 *2·70*	6 × 3 × ·32 *3·90*	5½ × 3 × ·37 *5·95*	6 × 3 × ·38 *7·35*	7 × 3 × ·37 *10·10*
28	4 × 3 × ·30 *1·65*	5 × 3 × ·36 *3·00*	6 × 3 × ·40 *4·75*	6 × 3 × ·35 *6·95*	6 × 3 × ·48 *8·75*	7 × 3 × ·48 *12·05*
32	4 × 3 × ·38 *2·10*	5 × 3 × ·42 *3·50*	5½ × 3 × ·37 *5·95*	6 × 3 × ·45 *8·35*	7 × 3 × ·39 *10·45*	8 × 3 × ·39 *14·10*
36	4 × 3 × ·40 *2·20*	6 × 3 × ·32 *3·90*	6 × 3 × ·35 *6·95*	6 × 3 × ·48 *8·75*	7 × 3 × ·47 *11·85*	8 × 3 × ·42 *14·75*
40	4 × 3 × ·43 *2·35*	6 × 3 × ·38 *4·55*	6 × 3 × ·36 *7·10*	7 × 3 × ·37 *10·10*	8 × 3 × ·39 *14·10*	8 × 3½ × ·52 *17·15*
44	5 × 3 × ·32 *2·70*	6 × 3 × ·40 *4·75*	6 × 3 × ·45 *8·35*	7 × 3 × ·48 *12·05*	8 × 3 × ·42 *14·75*	9 × 3½ × ·41 *19·15*
48	5 × 3 × ·36 *3·00*	5½ × 3 × ·35 *5·70*	6 × 3 × ·47 *8·60*	7 × 3 × ·49 *12·25*	8 × 3½ × ·49 *16·45*	9 × 3½ × ·45 *20·20*
52	5 × 3 × ·42 *3·50*	5½ × 3 × ·37 *5·95*	7 × 3 × ·37 *10·10*	8 × 3 × ·39 *14·10*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·52 *22·20*
56	5 × 3 × ·44 *3·65*	6 × 3 × ·35 *6·95*	7 × 3 × ·39 *10·45*	8 × 3 × ·42 *14·75*	9 × 3½ × ·45 *20·20*	9 × 3½ × ·60 *24·45*
60	6 × 3 × ·32 *3·90*	6 × 3 × ·36 *7·10*	7 × 3 × ·48 *12·05*	8 × 3½ × ·49 *16·45*	9 × 3½ × ·51 *21·90*	10 × 3½ × ·50 *27·40*

ANGLES

BULB ANGLES

Section moduli above are given to nearest ·05

NOTES.—TABLE 38

1. Depth is to be measured at mid-length of the tunnel from the bulkhead deck at the centre line to the base of the tunnel.

2. Correction for spacing. If the spacing of the stiffeners differs from 36 inches the Table modulus is to be modified in direct proportion.

3. Particulars of sections and moduli are given in Table 56.

TABLE 39

STIFFENERS TO NON

LENGTH OF STIFFENER		NUMERAL					
		NOT EXCEEDING 5	10	15	20	30	40
		← SINGLE STIFFENERS. →				← DOUBLE STIFFENERS. →	
Feet		Inches	Inches	Inches	Inches	Inches	Inches
8	ANGLES	4 × 3 × ·32	5 × 3 × ·36	5½ × 3 × ·34	6 × 3 × ·40	5 × 3 × ·30	5½ × 3 × ·38
10	ANGLES	5 × 3 × ·32	5½ × 3 × ·32	6 × 3 × ·34	7 × 3 × ·36	5½ × 3 × ·30	6 × 3 × ·38
12	ANGLES	5 × 3 × ·36	6 × 3 × ·32	7 × 3 × ·34	8 × 3 × ·36	6 × 3 × ·32	6 × 3 × ·44
14	ANGLES	5 × 3 × ·40	6 × 3 × ·38	7 × 3 × ·40	8 × 3 × ·42	6 × 3 × ·36	7 × 3 × ·42
16	BULB ANGLES	6 × 3 × ·32	7 × 3 × ·36	8 × 3 × ·36	9 × 3½ × ·40	7 × 3 × ·36	8 × 3 × ·42
18	BULB ANGLES	6 × 3 × ·38	7 × 3 × ·42	8 × 3 × ·42	9 × 3½ × ·46	7 × 3 × ·40	8 × 3 × ·46
20	BULB ANGLES	7 × 3 × ·38	8 × 3 × ·42	9 × 3½ × ·42	10 × 3½ × ·48	8 × 3 × ·40	9 × 3½ × ·44
22	BULB ANGLES	7 × 3 × ·44	8 × 3 × ·48	9 × 3½ × ·50	10 × 3½ × ·56	8 × 3 × ·44	9 × 3½ × ·50
24	BULB ANGLES	8 × 3 × ·40	9 × 3½ × ·44	10 × 3½ × ·48	11 × 3½ × ·54	9 × 3½ × ·42	10 × 3½ × ·48
26	BULB ANGLES	8 × 3 × ·46	9 × 3½ × ·50	10 × 3½ × ·54	11 × 3½ × ·60	9 × 3½ × ·46	10 × 3½ × ·54
28	BULB ANGLES	9 × 3½ × ·42	10 × 3½ × ·48	11 × 3½ × ·52	12 × 3½ × ·58	10 × 3½ × ·42	11 × 3½ × ·50
30	BULB ANGLES	9 × 3½ × ·48	10 × 3½ × ·54	11 × 3½ × ·56	12 × 3½ × ·62	10 × 3½ × ·46	11 × 3½ × ·56
32	BULB ANGLES	10 × 3½ × ·44	11 × 3½ × ·48	11 × 3½ × ·58	12 × 3½ × ·66	11 × 3½ × ·44	12 × 3½ × ·52

NOTES.—TABLE 39

1. Length of stiffener is to be measured between the top and bottom boundaries of the bulkhead.

2. The numeral, whether for stiffeners supporting deck beams, strong hatch end beams or deck transverses, is to be obtained as for pillars: *see* Table 31, notes 1 and 2.

3. Arrangements with longitudinally framed decks.—The stiffeners not supporting deck transverses are to have a modulus 25 per cent less than that derived from the column headed "Not exceeding 5". The ends of hold

TABLE 39

NUMERAL 50	NUMERAL 60	NUMERAL 70	NUMERAL 80	NUMERAL 90		LENGTH OF STIFFENER
DOUBLE STIFFENERS.					BULB ANGLES	
Inches	Inches	Inches	Inches	Inches		Feet
6 × 3 × ·38	6 × 3 × ·42	7 × 3 × ·42	8 × 3 × ·40	8 × 3 × ·46		8
6 × 3 × ·42	7 × 3 × ·42	7 × 3 × ·46	8 × 3 × ·44	8 × 3 × ·50		10
7 × 3 × ·42	8 × 3 × ·42	8 × 3 × ·46	8 × 3 × ·50	9 × 3½ × ·50		12
8 × 3 × ·40	8 × 3 × ·44	9 × 3½ × ·46	9 × 3½ × ·50	10 × 3½ × ·52		14
8 × 3 × ·46	9 × 3½ × ·46	9 × 3½ × ·52	10 × 3½ × ·52	10 × 3½ × ·58		16
9 × 3½ × ·44	9 × 3½ × ·50	10 × 3½ × ·52	10 × 3½ × ·56	11 × 3½ × ·56		18
9 × 3½ × ·50	10 × 3½ × ·50	10 × 3½ × ·58	11 × 3½ × ·56	11 × 3½ × ·60		20
10 × 3½ × ·50	10 × 3½ × ·56	11 × 3½ × ·56	11 × 3½ × ·60	12 × 3½ × ·60		22
10 × 3½ × ·56	11 × 3½ × ·54	12 × 3½ × ·56	12 × 3½ × ·60			24
11 × 3½ × ·54	11 × 3½ × ·60	12 × 3½ × ·60				26
11 × 3½ × ·60	12 × 3½ × ·60					28
12 × 3½ × ·56						30
12 × 3½ × ·60						32

NOTES.—TABLE 39 (*concluded*)

stiffeners are to be lugged or welded to the inner bottom and deck.

4. Coal bunker bulkheads.—The scantlings of stiffeners for bunker bulkheads, not supporting decks, are to be determined from the column headed "Not exceeding 5" for a spacing of 36 inches, but the modulus may be reduced by 25 per cent.

5. For end connections and constructional details *see* D 18.

TABLE 40 STIFFENERS ON BOUNDARY BULKHEADS OF DEEP TANKS

Spaced 24 inches apart

LENGTH OF STIFFENER		HEAD H FEET							
		3	4	5	6	8	10	12	14
Feet		INCHES *Modulus—Inches³*							
5	ANGLES	3 × 3 × ·26 ·85	3 × 3 × ·30 1·00	3½ × 3 × ·28 1·20	3½ × 3 × ·32 1·40	4 × 3 × ·34 1·90	4 × 3 × ·44 2·40	5 × 3 × ·33 2·80	5 × 3 × ·39 3·25
6	ANGLES	3 × 3 × ·30 1·00	3½ × 3 × ·32 1·40	4 × 3 × ·31 1·70	4 × 3 × ·38 2·10	5 × 3 × ·33 2·80	5 × 3 × ·41 3·40	6 × 3 × ·34 4·10	6 × 3 × ·39 4·65
7	ANGLES	3½ × 3 × ·32 1·40	4 × 3 × ·38 2·10	5 × 3 × ·30 2·55	5 × 3 × ·34 2·85	6 × 3 × ·32 3·90	6 × 3 × ·41 4·85	5½ × 3 × ·35 5·70	6 × 3 × ·32 6·50
8	ANGLES	4 × 3 × ·34 1·90	5 × 3 × ·30 2·55	5 × 3 × ·37 3·10	6 × 3 × ·30 3·70	6 × 3 × ·42 5·00	5½ × 3 × ·40 6·25	6 × 3 × ·39 7·50	6 × 3 × ·48 8·75
9	ANGLES	4 × 3 × ·44 2·40	5 × 3 × ·39 3·25	6 × 3 × ·33 4·00	6 × 3 × ·40 4·75	5½ × 3 × ·40 6·25	6 × 3 × ·42 7·90	6 × 3 × ·52 9·30	7 × 3 × ·41 10·80
10	ANGLES	5 × 3 × ·34 2·85	6 × 3 × ·34 4·10	6 × 3 × ·42 5·00	5½ × 3 × ·36 5·80	6 × 3 × ·42 7·90	7 × 3 × ·34 9·60	7 × 3 × ·46 11·65	8 × 3 × ·36 13·45
11	ANGLES	5 × 3 × ·42 3·55	6 × 3 × ·42 5·00	5½ × 3 × ·34 5·60	6 × 3 × ·36 7·10	7 × 3 × ·33 9·45	7 × 3 × ·45 11·50	8 × 3 × ·37 13·65	8 × 3 × ·46 15·65
12	ANGLES	6 × 3 × ·37 4·55	5½ × 3 × ·36 5·80	5½ × 3 × ·46 6·95	6 × 3 × ·44 8·20	7 × 3 × ·42 10·95	8 × 3 × ·36 13·45	8 × 3 × ·47 15·90	9 × 3½ × ·38 18·40
13	ANGLES	6 × 3 × ·43 5·10	5½ × 3 × ·43 6·60	6 × 3 × ·43 8·05	7 × 3 × ·34 9·60	7 × 3 × ·52 12·80	8 × 3 × ·48 16·10	9 × 3½ × ·41 19·15	9 × 3½ × ·50 21·60
14	BULB ANGLES	5½ × 3 × ·34 5·60	6 × 3 × ·38 7·35	6 × 3 × ·52 9·30	7 × 3 × ·44 11·30	8 × 3 × ·44 15·20	9 × 3½ × ·39 18·65	9 × 3½ × ·52 22·20	10 × 3½ × ·44 25·45
15	BULB ANGLES	6 × 3 × ·34 6·80	6 × 3 × ·50 9·00	7 × 3 × ·43 11·15	8 × 3 × ·36 13·45	8 × 3 × ·55 17·80	9 × 3½ × ·52 22·20	10 × 3½ × ·46 26·10	10 × 3½ × ·57 29·45
16	BULB ANGLES	6 × 3 × ·42 7·90	7 × 3 × ·40 10·60	7 × 3 × ·53 13·00	8 × 3 × ·44 15·20	9 × 3½ × ·47 20·80	10 × 3½ × ·43 25·15	10 × 3½ × ·56 29·45	11 × 3½ × ·48 33·05
17	BULB ANGLES	6 × 3 × ·52 9·15	7 × 3 × ·50 12·40	8 × 3 × ·44 15·20	8 × 3 × ·55 17·80	9 × 3½ × ·54 22·70	10 × 3½ × ·55 29·15	11 × 3½ × ·50 33·80	11 × 3½ × ·62 38·60
18	BULB ANGLES	7 × 3 × ·39 10·45	8 × 3 × ·39 14·10	8 × 3 × ·53 17·35	9 × 3½ × ·46 20·50	10 × 3½ × ·45 25·80	11 × 3½ × ·49 33·45	12 × 3½ × ·46 39·45	12 × 4 × 4 × ·46 45·40
19	BULB ANGLES	7 × 3 × ·49 12·15	8 × 3 × ·49 16·35	9 × 3½ × ·45 20·20	9 × 3½ × ·58 23·85	10 × 3½ × ·60 30·80	11 × 3½ × ·62 38·60	12 × 3½ × 3½ × ·54 45·30	12 × 4 × 4 × ·61 51·40
20	BULB ANGLES	8 × 3 × ·38 13·85	9 × 3½ × ·38 18·40	9 × 3½ × ·54 22·70	10 × 3½ × ·49 27·10	11 × 3½ × ·55 35·8	12 × 4 × 4 × ·44 44·60	12 × 4 × 4 × ·62 51·80	 58·70
21	BULB ANGLES	8 × 3 × ·46 15·75	9 × 3½ × ·48 21·05	10 × 3½ × ·46 26·10	 31·25	12 × 3½ × ·50 41·20	12 × 4 × 4 × ·60 51·00	 59·80	15 × 4 × 4 × ·50 65·85
22	BULB ANGLES	8 × 3 × ·55 17·80	9 × 3½ × ·58 23·85	10 × 3½ × ·56 29·45	11 × 3½ × ·54 35·40	12 × 4 × 4 × ·49 46·60	 57·60	15 × 4 × 4 × ·52 67·05	 76·90
23	BULB ANGLES	9 × 3½ × ·48 21·05	10 × 3½ × ·49 27·10	11 × 3½ × ·49 33·45	12 × 3½ × ·47 39·90	12 × 4 × 4 × ·64 52·60	15 × 4 × 4 × ·48 64·60	 76·90	17 × 4 × 4 × ·56 86·10
24	BULB ANGLES	10 × 3½ × ·40 24·20	10 × 3½ × ·58 30·10	11 × 3½ × ·57 37·40	12 × 3½ × 3½ × ·52 44·50	 59·40	15 × 4 × 4 × ·60 71·80	17 × 4 × 4 × ·56 86·10	17 × 4 × 4 × ·74 99·25

Section moduli above are given to nearest ·05

NOTES.—TABLE 40

1. Length of stiffeners on bulkheads is to be measured as follows :—

(*a*) Where horizontal girders are not fitted :
between the top and bottom boundaries.

(*b*) Where horizontal girders are fitted :

(i) between the top boundary and the highest girder,

(ii) between girder and girder,

(iii) between the lowest girder and the bottom boundary.

On tunnels passing through deep tanks and having a curved top, the length of stiffeners is to be measured from the base of the tunnel to the top of the flat side.

2. Head H is to be taken as the greater of the two following values :—

(*a*) the distance in feet from the mid-point of length as defined above to the top of the tank.

TABLE 40

Spaced 24 inches apart

HEAD H FEET							LENGTH OF STIFFENER	
16	18	20	22	24	26	28		
INCHES *Modulus—Inches³*							Feet	
5 × 3 × ·44 *3·65*	6 × 3 × ·34 *4·10*	6 × 3 × ·37 *4·40*	6 × 3 × ·40 *4·75*	6 × 3 × ·44 *5·20*	5½ × 3 × ·36 *5·80*	6 × 3 × ·36 *7·10*	BULB ANGLES	5
6 × 3 × ·44 *5·20*	5½ × 3 × ·36 *5·80*	6 × 3 × ·31 *6·40*	6 × 3 × ·36 *7·10*	6 × 3 × ·40 *7·65*	6 × 3 × ·44 *8·20*	6 × 3 × ·48 *8·75*		6
6 × 3 × ·38 *7·35*	6 × 3 × ·44 *8·20*	6 × 3 × ·50 *9·00*	7 × 3 × ·36 *9·95*	7 × 3 × ·40 *10·60*	7 × 3 × ·44 *11·30*	7 × 3 × ·48 *12·05*		7
7 × 3 × ·35 *9·80*	7 × 3 × ·42 *10·95*	7 × 3 × ·48 *12·05*	8 × 3 × ·35 *13·25*	8 × 3 × ·39 *14·10*	8 × 3 × ·43 *15·00*	8 × 3 × ·47 *15·90*		8
7 × 3 × ·49 *12·25*	8 × 3 × ·37 *13·65*	8 × 3 × ·44 *15·20*	8 × 3 × ·49 *16·35*	8 × 3 × ·55 *17·80*	9 × 3½ × ·41 *19·15*	9 × 3½ × ·45 *20·20*		9
8 × 3 × ·44 *15·20*	8 × 3 × ·51 *16·85*	9 × 3½ × ·39 *18·65*	9 × 3½ × ·46 *20·50*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·55 *23·00*	10 × 3½ × ·42 *24·80*		10
8 × 3 × ·54 *17·55*	9 × 3½ × ·42 *19·40*	9 × 3½ × ·50 *21·60*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·41 *24·50*	10 × 3½ × ·48 *26·80*	10 × 3½ × ·54 *28·80*		11
9 × 3½ × ·46 *20·50*	9 × 3½ × ·54 *22·70*	10 × 3½ × ·43 *25·15*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·44 *31·55*	11 × 3½ × ·49 *33·45*		12
10 × 3½ × ·41 *24·50*	10 × 3½ × ·50 *27·40*	10 × 3½ × ·56 *29·45*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·46 *39·45*		13
10 × 3½ × ·54 *28·80*	11 × 3½ × ·46 *32·30*	11 × 3½ × ·53 *35·00*	11 × 3½ × ·59 *37·40*	12 × 3½ × ·48 *40·30*	12 × 3½ × 3½ × ·48 *43·00*	12 × 3½ × 3½ × ·54 *45·30*		14
11 × 3½ × ·48 *33·05*	11 × 3½ × ·57 *36·60*	12 × 3½ × ·48 *40·30*	12 × 3½ × 3½ × ·48 *43·00*	12 × 4 × 4 × ·50 *47·00*	12 × 4 × 4 × ·62 *51·80*	 *53·60*		15
11 × 3½ × ·59 *37·40*	12 × 3½ × ·50 *41·20*	12 × 3½ × 3½ × ·54 *45·30*	12 × 4 × 4 × ·58 *50·20*	 *53·70*	 *57·60*	15 × 4 × 4 × ·44 *62·15*		16
12 × 3½ × ·54 *43·05*	12 × 4 × 4 × ·52 *47·80*	12 × 4 × 4 × ·64 *52·60*	 *57·60*	15 × 4 × 4 × ·44 *62·15*				17
12 × 4 × 4 × ·58 *50·20*	 *56·50*	15 × 4 × 4 × ·44 *62·15*					CHANNELS	18
 58·70	15 × 4 × 4 × ·50 *65·85*	15 × 4 × 4 × ·60 *71·80*						19
15 × 4 × 4 × ·50 *65·85*	15 × 4 × 4 × ·63 *73·60*	17 × 4 × 4 × ·50 *81·60*						20
 76·00	17 × 4 × 4 × ·54 *84·60*							21
17 × 4 × 4 × ·58 *87·55*	17 × 4 × 4 × ·70 *96·35*							22
17 × 4 × 4 × ·75 *99·95*								23
								24

Section moduli above are given to nearest ·05

NOTES.—TABLE 40 (*concluded*)

(*b*) half the distance in feet from the mid-point of length as defined above to the top of the overflow.

3. Correction for spacing. Where the spacing of the stiffeners differs from 24 inches, the modulus is to be modified in direct proportion.

4. Welded construction. When the bulkhead plating, boundaries, stiffeners and end brackets are welded and the stiffeners are not supported by horizontal girders, the modulus of the stiffeners may, in general, be reduced by 15 per cent, but due consideration is to be given to stiffness and to the rigidity of the structure to which the end brackets are attached.

5. Riveted end attachments are to be in accordance with the requirements of Table 36.

6. Particulars of sections and moduli are given in Table 56.

TABLE 41 HORIZONTAL GIRDERS IN OIL FUEL BUNKERS

NUMERAL	GIRDER		NUMERAL	GIRDER		NUMERAL	GIRDER	
	WEB PLATE	FACE AREA		WEB PLATE	FACE AREA		WEB PLATE	FACE AREA
	Inches	Square inches		Inches	Square inches		Inches	Square inches
50	12 × ·34	1·3	500	34 × ·42	6·2	950	48 × ·46	9·8
100	16 × ·34	2·1	550	36 × ·42	6·6	1000	48 × ·46	10·7
150	19 × ·34	2·9	600	37 × ·44	7·4	1100	49 × ·46	12·0
200	22 × ·36	3·5	650	39 × ·44	7·7	1200	52 × ·46	12·0
250	24 × ·36	4·0	700	41 × ·46	8·0	1300	54 × ·48	12·0
300	27 × ·36	4·0	750	43 × ·46	8·3	1400	57 × ·50	12·0
350	29 × ·38	4·5	800	45 × ·46	8·5	1500	60 × ·50	12·0
400	31 × ·38	4·9	850	47 × ·46	8·5			
450	33 × ·40	5·1	900	48 × ·46	8·9			

NOTES.—TABLE 41

1. Numeral = $\frac{s^2 \times d \times H}{100}$

where s = length, in feet, between centres of end brackets.

d = depth, in feet, between the centres of the two adjacent spans of stiffeners or frames supported by the girder.

H = the greater of the two following values :—

(*a*) the distance, in feet, from the girder to the top of the tank.

(*b*) half the distance, in feet, from the girder to the top of the overflow.

2. For tanks which exceed 30 feet in length the scantlings and arrangements will be specially considered.

3. The face area of girders derived from the Table may take the form of rolled sections, flanged girder plates or welded face plates, the width of the girder being the extreme width of the web plate.

4. For end connections and constructional details *see* D 2006 to D 2010.

A—RIVETED

BREADTH OF HATCHWAY	WEB PLATE — BEAM SPACING CENTRE TO CENTRE				DOUBLE ANGLES ON EDGES OF BEAMS
	Feet 4	Feet 5	Feet 6	Feet 7	
Feet	INCHES — *Modulus—Inches*³				Inches
10	*15*	*20*	11 × ·30 *42*	11½ × ·32 *45*	3 × 3 × ·40
12	10 × ·38 B.P. *26*	10 × ·44 B.P. *28*	12 × ·32 *48*	13 × ·34 *54*	3 × 3 × ·40
14	10 × ·46 B.P. *29*	12 × ·32 *50*	14 × ·34 *64*	15½ × ·36 *72*	3 × 3 × ·42
16	12 × ·32 *54*	14 × ·34 *68*	16 × ·36 *82*	17½ × ·38 *93*	3½ × 3 × ·42
18	14 × ·34 *76*	16 × ·36 *91*	18 × ·36 *107*	19½ × ·38 *120*	4 × 3 × ·44
20	15 × ·34 *83*	18 × ·36 *107*	20 × ·38 *124*	22 × ·38 *141*	4 × 3 × ·44
22	16 × ·36 *100*	19 × ·36 *126*	22 × ·38 *154*	24 × ·40 *170*	4 × 3 × ·50
24	17 × ·36 *120*	20 × ·38 *150*	23 × ·40 *182*	25½ × ·42 *210*	5 × 3½ × ·46
26	18 × ·36 *142*	21 × ·38 *175*	24 × ·40 *210*	26½ × ·42 *241*	5 × 3½ × ·52
28	19 × ·38 *167*	22 × ·38 *202*	25 × ·40 *240*	28 × ·42 *280*	6 × 3½ × ·50
30	20 × ·38 *184*	23 × ·40 *222*	26 × ·42 *261*	29 × ·44 *303*	6 × 3½ × ·52

B—RIVETED

10	7 × ·36 B.P. *11*	*15*	*17*	*20*	3 × 3 × ·40
12	*15*	*20*	*24*	*32*	3 × 3 × ·40
14	*20*	10 × ·38 B.P. *26*	11 × ·30 *44*	12 × ·32 *50*	3 × 3 × ·42
16	11 × ·30 *48*	11 × ·30 *48*	12 × ·32 *54*	13½ × ·34 *64*	3½ × 3 × ·42
18	11 × ·30 *54*	12 × ·32 *61*	14 × ·34 *76*	15½ × ·36 *87*	4 × 3 × ·44
20	12 × ·32 *61*	13 × ·34 *69*	16 × ·36 *91*	17½ × ·36 *103*	4 × 3 × ·44
22	12½ × ·32 *71*	14 × ·34 *83*	17 × ·36 *109*	18½ × ·38 *123*	4 × 3 × ·50
24	13 × ·34 *84*	14½ × ·34 *97*	18 × ·36 *128*	19½ × ·38 *145*	5 × 3½ × ·46
26	13½ × ·34 *97*	15 × ·34 *112*	19 × ·38 *154*	20½ × ·38 *170*	5 × 3½ × ·52
28	14 × ·34 *112*	16 × ·36 *133*	20 × ·38 *179*	21½ × ·38 *196*	6 × 3½ × ·50
30	15 × ·34 *126*	17 × ·36 *149*	21 × ·38 *196*	22½ × ·38 *214*	6 × 3½ × ·52

For notes see page 146

TABLE 43 C HATCHWAY BEAMS

C—WELDED

DEPTH OF BEAM OVER FACE PLATES	BASIC WEB THICKNESS	* CORRECTION TO MODULUS PER ·05 INCH VARIATION IN WEB THICKNESS	BASIC FLANGE THICKNESS	† CORRECTION TO MODULUS PER ·10 INCH VARIATION IN FLANGE THICKNESS	AREA OF EACH FACE PLATE SQUARE INCHES.									
					3	4	5	6	7	8	9	10	11	12
					MODULUS									
Inches	Inches	Inches³	Inches	Inches³	← Inches³ →									
8	·35	·5	·60	1·0	23	30	36							
10	·35	·5	·60	1·0	30	39	48							
12	·40	1·0	·70	1·5		49	60	70						
14	·40	1·5	·70	1·5		60	73	85	98					
16	·45	2·0	·80	2·0			86	101	115	130				
18	·45	2·5	·80	2·0			101	117	133	150	166			
20	·50	3·0	·90	2·5				134	153	171	190	207		
22	·50	3·5	·90	3·0				152	173	193	213	233	254	
24	·55	4·0	1·0	3·5					195	217	239	261	283	305

*When the thickness of the web is increased the modulus is to be increased by the appropriate correction
†When the thickness of the flange is increased the modulus is to be reduced by the appropriate correction

NOTES.—TABLE 43

1. Scantlings of riveted hatchway beams are to be determined from the Table as follows :—

For hatchways requiring coamings 24 inches in height (D 2301 to D 2302), in ships 200 feet or more in length ... ... A

in ships 100 feet or less in length ... ... B

(For intermediate lengths scantlings are to be determined by interpolation.)

For hatchways requiring coamings 18 inches in height, or less, except in cargo spaces ... ... B

For hatchways in cargo spaces (*see also* note 4) ... A

For hatchways in accommodation spaces ... ... B

2. The Table depth of hatchway beams is to be measured at mid-length from the top of the upper mounting angles to the bottom of the lower mounting angles or bulb plate. The depth of the ends may be half that at the centre but is not to be less than 6 inches. Alternative arrangements may be adopted if suitable strength is provided at the ends of the webs. The larger flange of the mountings is to be fitted horizontally.

3. Scantlings of welded hatchway beams may be obtained from C on the basis of modulus equivalent to the requirements of A or B. The width of the face plates is to be sufficient to provide the minimum hatch bearing surface required by D 2312.

4. Where the 'tween deck height in cargo spaces and trunked hatchways (*see* D 2329) exceeds 8 feet 6 inches the modulus of the hatchway beams is to be increased in direct proportion.

5. For construction details *see* D 2309 to D 2315.
For riveting and welding *see* Table 52 H.

6. Where built steel hatchway covers are fitted, the scantlings are to be in accordance with the following formulæ :

	Type A (Note 1)	Type B (Note 1)
Section Modulus of stiffeners (including plating) in inches³	·04 SL^2	·03 SL^2
Moment of inertia of stiffeners (including plating) in inches⁴	·008 SL^3	·006 SL^3

Where L = unsupported span of stiffeners, in feet.
S = spacing of stiffeners, in feet.

Thickness of plating in inches $\cdot 26+\frac{s-24}{150}$ $\cdot 24+\frac{s-24}{200}$

Where s = spacing of stiffeners, in inches.

For pontoon hatch covers, *see* D 2325.

NUMERAL	SEA SPEED IN KNOTS						
	10 and below	12	14	16	18	20	22
	DIAMETER OF RUDDER HEAD						
	Inches	Inches	Inches	Inches	Inches	Inches	Inches
30	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$			
40	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$			
50	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	$5\frac{1}{4}$			
60	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{2}$			
70	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{3}{4}$			
80	5	$5\frac{1}{4}$	$5\frac{1}{2}$	6			
90	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{1}{4}$	$6\frac{3}{4}$		
100	$5\frac{1}{2}$	$5\frac{3}{4}$	$6\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$		
120	6	$6\frac{1}{4}$	$6\frac{3}{4}$	$7\frac{1}{4}$	$7\frac{3}{4}$		
140	$6\frac{1}{4}$	$6\frac{1}{2}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	
160	$6\frac{3}{4}$	7	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	
190	$7\frac{1}{4}$	$7\frac{1}{2}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	
220	$7\frac{3}{4}$	8	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{3}{4}$
260	$8\frac{1}{4}$	$8\frac{1}{2}$	9	$9\frac{1}{2}$	10	$10\frac{1}{2}$	$11\frac{1}{4}$
300	$8\frac{1}{2}$	$8\frac{3}{4}$	$9\frac{1}{4}$	$9\frac{3}{4}$	$10\frac{1}{2}$	11	$11\frac{3}{4}$
350	9	$9\frac{1}{4}$	$9\frac{3}{4}$	$10\frac{1}{4}$	11	$11\frac{1}{2}$	$12\frac{1}{4}$
400	$9\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{1}{4}$	$10\frac{3}{4}$	$11\frac{1}{2}$	12	13
450	10	10	$10\frac{1}{2}$	11	12	$12\frac{1}{2}$	$13\frac{1}{2}$
510	$10\frac{1}{2}$	$10\frac{1}{2}$	11	$11\frac{1}{2}$	$12\frac{1}{2}$	13	14
570	11	11	$11\frac{1}{2}$	12	13	$13\frac{1}{2}$	$14\frac{3}{4}$
640	$11\frac{1}{2}$	$11\frac{1}{2}$	12	$12\frac{1}{2}$	$13\frac{1}{2}$	$14\frac{1}{4}$	$15\frac{1}{2}$
720	12	12	$12\frac{1}{2}$	13	14	15	16
800	$12\frac{1}{2}$	$12\frac{1}{2}$	13	$13\frac{1}{2}$	$14\frac{1}{2}$	$15\frac{1}{2}$	$16\frac{1}{2}$
890	13	13	$13\frac{1}{2}$	14	15	16	17
980	$13\frac{1}{2}$	$13\frac{1}{2}$	14	$14\frac{1}{2}$	$15\frac{1}{2}$	$16\frac{1}{2}$	$17\frac{1}{2}$
1080	14	14	$14\frac{1}{2}$	$15\frac{1}{4}$	$16\frac{1}{4}$	$17\frac{1}{4}$	$18\frac{1}{4}$
1180	$14\frac{1}{2}$	$14\frac{1}{2}$	15	16	17	18	19
1290	15	15	$15\frac{1}{2}$	$16\frac{1}{2}$	$17\frac{1}{2}$	$18\frac{1}{2}$	$19\frac{1}{2}$
1400	$15\frac{1}{2}$	$15\frac{1}{2}$	16	17	18	19	20

NOTES.—TABLE 44

1. Numeral.—(*a*) The numeral = A × D where :

A = total area of rudder in square feet, including balanced portion, if any.

D = distance in feet of centre of gravity of area A from the centre line of the pintles.

(*b*) For balanced rudders the numeral is not to be less than 80 per cent of that derived from the part of the rudder abaft the centre line of the pintles.

2. For rudders strengthened for Navigation in ice *see* D 1006, D 1014 and D 1022.

3. Where steel complying with P 610 or scrap material (*see* D 2603) is used the diameter of rudder head is to be increased by 5 per cent.

TABLE 45

SINGLE PLATE RUDDERS

DIAMETER OF RUDDER HEAD, TABLE 44	ARMS—SPACED 48 INCHES BETWEEN CENTRES				PLATE	DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE
	BREADTH	THICKNESS				
		AT MAINPIECE	ROUND MAINPIECE	AT END		
Inches	Inches	Inches	Inches	Inches	Inches	Inches
3	3	2	$1\frac{3}{8}$	$\frac{3}{4}$	·78	$\frac{7}{8}$
4	4	$2\frac{3}{8}$	$1\frac{3}{4}$	$\frac{7}{8}$	·80	1
5	5	$2\frac{3}{4}$	$2\frac{1}{8}$	1	·82	$1\frac{1}{8}$
6	$5\frac{1}{2}$	$3\frac{1}{8}$	$2\frac{1}{4}$	1	·84	$1\frac{1}{8}$
7	6	$3\frac{5}{8}$	$2\frac{1}{2}$	1	·86	$1\frac{1}{8}$
8	$6\frac{1}{2}$	4	$2\frac{3}{4}$	1	·88	$1\frac{1}{4}$
9	7	$4\frac{1}{4}$	3	1	·90	$1\frac{1}{4}$
10	$7\frac{1}{2}$	$4\frac{5}{8}$	$3\frac{1}{4}$	$1\frac{1}{8}$	·92	$1\frac{1}{4}$
11	8	5	$3\frac{1}{2}$	$1\frac{1}{8}$	·94	$1\frac{1}{4}$
12	$8\frac{1}{2}$	$5\frac{3}{8}$	$3\frac{5}{8}$	$1\frac{1}{8}$	·96	$1\frac{1}{4}$
13	$8\frac{3}{4}$	$5\frac{3}{4}$	$3\frac{3}{4}$	$1\frac{1}{8}$	·96	$1\frac{1}{4}$
14	9	6	$3\frac{7}{8}$	$1\frac{1}{8}$	·98	$1\frac{1}{4}$
15	$9\frac{1}{4}$	$6\frac{1}{4}$	4	$1\frac{1}{8}$	·98	$1\frac{1}{4}$

NOTES.—TABLE 45

Corrections for spacing of arms.—The breadth of the arms is to be modified directly as the spacing.

The thickness of the plate is to be modified with the spacing at the rate of ·01 inch for every inch increase or reduction from 48 inches.

DOUBLE PLATE RUDDERS

SIDE PLATES

DIAMETER OF RUDDER HEAD TABLE 44	SPACING OF ARMS BETWEEN CENTRES INCHES			SOLID FRAMES
	FORGED & CAST FRAMES			DIAMETER OF RIVETS SPACED 4½ DIAMETERS APART CENTRE TO CENTRE
	36	48	60	
	PLATE FRAMES			
	24	36	48	
Inches	Inches	Inches	Inches	Inches
4	·36	·46		$\frac{3}{4}$
5	·37	·47		$\frac{3}{4}$
6	·39	·49		$\frac{7}{8}$
7	·40	·50	·60	$\frac{7}{8}$
8	·41	·51	·61	$\frac{7}{8}$
9	·42	·52	·62	$\frac{7}{8}$
10	·44	·54	·64	1
11	·45	·55	·66	1
12	·46	·56	·67	1
13	·48	·57	·69	1
14	·49	·59	·70	1
15	·50	·60	·72	1

NOTES.—TABLE 46

1. **Plate thickness.**—When the ratio of the fore and aft dimension to the vertical dimension of the unsupported panels of plating exceeds 3:2 an additional vertical diaphragm is to be fitted.

The thickness of side plates of rudder with a plate frame may require to be increased in way of the vertical webs which replace the mainpiece.

The thickness of the nose plate is not to be less than that required for the side plates at a 48 inch spacing of plate frames.

2. **Plate frames.**—Horizontal webs and vertical webs not replacing the mainpiece are to have the same thickness as the side plates, but the plates forming the top and bottom of the rudder are to be of increased thickness.

Vertical webs replacing the mainpiece are to have a thickness equal to twice the Table thickness of side plates for 30 inches spacing.

TABLE 47 RUDDER PINTLES

ONE OR TWO PINTLES

BALANCED OR UNBALANCED RUDDERS

AREA SUPPORTED (*See* NOTE 1)	SEA SPEED IN KNOTS					
	12 and below	14	16	18	20	22
	DIAMETER OF PINTLES					
Square feet	Inches	Inches	Inches	Inches	Inches	Inches
10	3·0	3·4	3·8			
20	4·2	4·7	5·2			
40	6·0	6·2	6·6	7·4	8·2	
60	7·4	7·4	7·8	8·6	9·6	
80	8·0	8·0	8·4	9·2	10·4	11·8
100		8·6	9·0	9·8	11·0	12·8
120		9·2	9·6	10·6	12·0	13·8
140		9·8	10·2	11·4	12·8	14·8
160			11·0	12·2	13·6	15·8
180			11·8	13·0	14·8	17·0
200			12·6	13·8	15·8	18·0

THREE OR MORE PINTLES

UNBALANCED RUDDERS

AREA SUPPORTED (*See* NOTE 1)	SEA SPEED IN KNOTS				
	12 and below	14	16	18	20
	DIAMETER OF PINTLES				
Square feet	Inches	Inches	Inches	Inches	Inches
10	2·4	2·8	3·2		
20	3·8	4·2	4·6		
30	5·0	5·4	5·8		
40	6·0	6·2	6·6	7·4	
50	6·8	6·9	7·2	8·0	
60	7·4	7·4	7·8	8·6	9·6

NOTES.—TABLE 47

1. Area supported.—When there is one pintle only the area supported is that below a horizontal line half way between the pintle and the top of the rudder.

Where there are two pintles the areas supported are those bounded by a horizontal line midway between the two pintles.

Where there are more than two pintles the area supported is to be taken as the total area of the rudder divided by the number of pintles.

2. Pintles.—The diameter of pintles obtained from the Table is to be measured outside the liner, if fitted.

The bearing length is to be 20 per cent greater than the diameter except that, where three or more pintles are fitted the bearing length of the bottom pintle need only be equal to the diameter.

The length of pintle housing in the rudder gudgeons is to be 20 per cent greater than the diameter of the pintle.

Pintles are to be fitted as taper bolts, the taper not being greater than 1 in 12 on the radius.

DIAMETER OF RUDDER HEAD TABLE 44	HORIZONTAL COUPLING		VERTICAL COUPLING		SCARPHED COUPLING					
	6 BOLTS		8 BOLTS			WIDTH OF SCARPHS		BOLTS		
	MEAN DISTANCE OF CENTRES OF BOLTS FROM CENTRE OF COUPLING	DIAMETER OF BOLTS AND THICKNESS OF FLANGES	WIDTH OF COUPLING	DIAMETER OF BOLTS AND THICKNESS OF FLANGES	LENGTH OF SCARPH	AT TOP	AT BOTTOM	NUMBER		DIAMETER
								TOTAL	IN TOP ROW	
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches			Inches
3½	4	1⅛								
3¾	4	1⅛								
4	4¼	1¼								
4¼	4¼	1¼								
4½	4½	1⅜	12	1⅜	13½	9	15	6	2	1½
4¾	4½	1⅜	12	1⅜	13½	9	15	6	2	1½
5	4½	1⅜	12	1⅜	13½	9	15	6	2	1½
5¼	4¾	1½	12	1½	13½	9	15	6	2	1½
5½	5	1½	12½	1½	14	9½	15½	6	2	1⅝
5¾	5¼	1½	13	1½	14½	10	16	6	2	1¾
6	5½	1⅝	13½	1⅝	15	10½	16½	6	2	1⅞
6¼	5¾	1¾	14	1¾	15¾	11	17¼	6	2	2
6½	6	1⅞	14½	1⅞	16¼	11½	18	6	2	2⅛
6¾	6¼	1⅞	15	1⅞	17	12	18¾	6	2	2⅛
7	6½	2	15¾	2	17½	12¼	19½	6	2	2¼
7¼	6¾	2⅛	16¼	2⅛	18	12¾	20	6	2	2¼
7½	7	2⅛	16¾	2⅛	18¾	13¼	21	7	2	2⅛
7¾	7¼	2¼	17¼	2¼	19½	13½	21½	7	2	2⅛
8	7½	2⅜	18	2⅜	20	14	22	7	2	2¼
8½	7¾	2½	19	2½	21¼	15	24	7	2	2½
9	8¼	2¾	20	2¾	22½	15¾	25	7	2	2⅝
9½	8½	2⅞	21¼	2⅞	23¾	16¾	26	7	2	2¾
10	9	3	22½	3	25	17½	27½	7	2	2⅞
10½	9½	3⅛	23½	3⅛	26¼	18½	29	8	2	2⅞
11	10	3¼	24¾	3¼	27½	19¼	30	8	2	3
11½	10½	3⅜	26	3⅜	28¾	20¼	31½	8	2	3⅛
12	10¾	3½	27	3½	30	21	33	8	2	3¼
12½	11¼	3⅝	28	3⅝	31¼	25	34½	9	3	3¼
13	11¾	3¾	29	3¾	32½	26	36	9	3	3¼
13½	12¼	3⅞	30	3⅞	33¾	27	37½	9	3	3⅜
14	12¾	4	31½	4	35	28	39	9	3	3⅝
14½	13	4⅛	32½	4⅛	36¼	29	40	9	3	3¾
15	13½	4¼	33½	4¼	37½	30	41	9	3	3⅞

NOTES.—TABLE 48

1. The width of material in the flanges, or palms of scarphs, outside the bolt holes is not to be less than two thirds of the diameter of the bolt.

2. In scarphed couplings the athwartship dimension at the top of the scarph is not to be less than the diameter of the rudder head. The thickness of the tips of the palms is not to be less than thirteen per cent of the diameter of the rudder head.

TABLE 49 STEERING CHAINS, RODS, QUADRANTS AND TILLERS

DIAMETER OF RUDDER HEAD TABLE 44	DIAMETER OF WROUGHT IRON CHAINS	DIAMETER OF RODS	RADIUS OF QUADRANT	BOSS OF QUADRANT		QUADRANTS AND TILLERS		
						Sizes of arms at twice the diameter of rudder head from centre of rudder head		
				Depth	Outside diameter	One arm	Two arms	Three arms
Inches	Inches	Inches	Feet Inches	Inches	Inches	Inches	Inches	Inches
$3\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	3 — 2	$3\frac{1}{2}$	$6\frac{1}{4}$	$3\frac{1}{2} \times 2\frac{1}{2}$		
$3\frac{3}{4}$	$\frac{9}{16}$	$\frac{5}{8}$	3 — 3	$3\frac{3}{4}$	$6\frac{3}{4}$	$4 \times 2\frac{1}{2}$		
4	$\frac{5}{8}$	$\frac{11}{16}$	3 — 4	4	$7\frac{1}{4}$	$4\frac{1}{4} \times 2\frac{1}{2}$		
$4\frac{1}{4}$	$\frac{11}{16}$	$\frac{3}{4}$	3 — 5	$4\frac{1}{4}$	$7\frac{1}{2}$	$4\frac{1}{2} \times 2\frac{3}{4}$		
$4\frac{1}{2}$	$\frac{11}{16}$	$\frac{3}{4}$	3 — 6	$4\frac{1}{2}$	8	$5 \times 2\frac{3}{4}$	$3\frac{3}{4} \times 2\frac{1}{4}$	
$4\frac{3}{4}$	$\frac{3}{4}$	$\frac{13}{16}$	3 — 7	$4\frac{3}{4}$	$8\frac{1}{2}$	$5\frac{1}{4} \times 2\frac{3}{4}$	$4 \times 2\frac{1}{4}$	
5	$\frac{3}{4}$	$\frac{13}{16}$	3 — 8	5	9	$5\frac{1}{2} \times 3$	$4\frac{1}{4} \times 2\frac{1}{2}$	
$5\frac{1}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	3 — 9	$5\frac{1}{4}$	$9\frac{1}{4}$	$5\frac{3}{4} \times 3$	$4\frac{1}{2} \times 2\frac{1}{2}$	
$5\frac{1}{2}$	$\frac{13}{16}$	$\frac{15}{16}$	3 — 10	$5\frac{1}{2}$	$9\frac{3}{4}$	$6 \times 3\frac{1}{4}$	$4\frac{3}{4} \times 2\frac{1}{2}$	
$5\frac{3}{4}$	$\frac{7}{8}$	$\frac{15}{16}$	3 — 11	$5\frac{3}{4}$	$10\frac{1}{4}$	$6\frac{1}{4} \times 3\frac{1}{4}$	$5 \times 2\frac{1}{2}$	
6	$\frac{7}{8}$	1	4 — 0	6	$10\frac{3}{4}$	$6\frac{1}{2} \times 3\frac{1}{2}$	$5\frac{1}{4} \times 2\frac{3}{4}$	
$6\frac{1}{4}$	$\frac{15}{16}$	$1\frac{1}{16}$	4 — 1	$6\frac{1}{4}$	$11\frac{1}{1}$	$6\frac{3}{4} \times 3\frac{1}{2}$	$5\frac{1}{2} \times 2\frac{3}{4}$	
$6\frac{1}{2}$	$\frac{15}{16}$	$1\frac{1}{16}$	4 — 2	$6\frac{1}{2}$	$11\frac{3}{4}$	$7 \times 3\frac{3}{4}$	$5\frac{1}{2} \times 3$	
$6\frac{3}{4}$	1	$1\frac{1}{8}$	4 — 3	$6\frac{3}{4}$	12	$7\frac{1}{4} \times 3\frac{3}{4}$	$5\frac{3}{4} \times 3$	
7	1	$1\frac{1}{4}$	4 — 4	7	$12\frac{1}{2}$	$7\frac{1}{2} \times 4$	$6 \times 3\frac{1}{4}$	
$7\frac{1}{4}$	$1\frac{1}{16}$	$1\frac{1}{4}$	4 — 5	$7\frac{1}{4}$	13	$7\frac{3}{4} \times 4\frac{1}{4}$	$6 \times 3\frac{1}{4}$	
$7\frac{1}{2}$	$1\frac{1}{16}$	$1\frac{5}{16}$	4 — 6	$7\frac{1}{2}$	$13\frac{1}{2}$	$8 \times 4\frac{1}{2}$	$6\frac{1}{4} \times 3\frac{1}{2}$	
$7\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{3}{8}$	4 — 7	$7\frac{3}{4}$	14	$8\frac{1}{4} \times 4\frac{1}{2}$	$6\frac{1}{4} \times 3\frac{3}{4}$	
8	$1\frac{3}{16}$	$1\frac{3}{8}$	4 — 8	8	$14\frac{1}{2}$	$8\frac{1}{2} \times 4\frac{3}{4}$	$6\frac{1}{2} \times 4$	$5\frac{3}{4} \times 3\frac{1}{2}$
$8\frac{1}{2}$	$1\frac{1}{4}$	$1\frac{1}{2}$	5 — 0	$8\frac{1}{2}$	$15\frac{1}{4}$	9×5	7×4	$6 \times 3\frac{3}{4}$
9	$1\frac{5}{16}$	$1\frac{9}{16}$	5 — 4	9	$16\frac{1}{4}$	$9\frac{1}{2} \times 5\frac{1}{1}$	$7\frac{1}{2} \times 4\frac{1}{4}$	$6\frac{1}{2} \times 3\frac{3}{4}$
$9\frac{1}{2}$	$1\frac{3}{8}$	$1\frac{11}{16}$	5 — 8	$9\frac{1}{2}$	17	$10 \times 5\frac{3}{4}$	$8 \times 4\frac{1}{2}$	7×4
10	$1\frac{7}{16}$	$1\frac{3}{4}$	6 — 0	10	18	$10\frac{1}{2} \times 6$	$8\frac{1}{2} \times 4\frac{1}{2}$	$7\frac{1}{2} \times 4$
$10\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{7}{8}$	6 — 4	$10\frac{1}{2}$	19	$11 \times 6\frac{1}{4}$	$9 \times 4\frac{3}{4}$	8×4
11	$1\frac{9}{16}$	$1\frac{15}{16}$	6 — 8	11	$19\frac{3}{4}$	$11\frac{1}{2} \times 6\frac{3}{4}$	$9\frac{1}{2} \times 5$	$8\frac{1}{2} \times 4\frac{1}{2}$
$11\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{15}{16}$	7 — 0	$11\frac{1}{2}$	$20\frac{3}{4}$	12×7	$10 \times 5\frac{1}{4}$	$8\frac{1}{2} \times 5$
12	$1\frac{5}{8}$	2	7 — 4	12	$21\frac{1}{2}$	$12\frac{1}{2} \times 7\frac{1}{2}$	$10\frac{1}{2} \times 5\frac{1}{2}$	9×5
$12\frac{1}{2}$			7 — 8	$12\frac{1}{2}$	$22\frac{1}{2}$	$13 \times 7\frac{1}{2}$	$11 \times 5\frac{1}{2}$	$9\frac{1}{2} \times 5$
13			8 — 0	13	$23\frac{1}{2}$	$13\frac{1}{2} \times 7\frac{1}{2}$	$11\frac{1}{4} \times 5\frac{3}{4}$	10×5
$13\frac{1}{2}$			8 — 0	$13\frac{1}{2}$	$24\frac{1}{2}$	14×8	$11\frac{1}{2} \times 6$	$10 \times 5\frac{1}{4}$
14			8 — 0	14	$25\frac{1}{4}$	$14\frac{1}{2} \times 8$	12×6	$10\frac{1}{2} \times 5\frac{1}{4}$
$14\frac{1}{2}$			8 — 0	$14\frac{1}{2}$	$26\frac{1}{4}$	$15 \times 8\frac{1}{2}$	$12\frac{1}{4} \times 6\frac{1}{2}$	$10\frac{1}{2} \times 5\frac{1}{2}$
15			8 — 0	15	27	$15\frac{1}{2} \times 8\frac{1}{2}$	$12\frac{3}{4} \times 6\frac{1}{2}$	$11 \times 5\frac{1}{2}$

NOTE—TABLE 49

Where special steel short link chains (*see* P 1301 Grade III) are used, the diameter given in column 2 above may be reduced as follows:—

Table size inches	*Reduction inches*
$1\frac{5}{16}$ and below	$\frac{1}{16}$
$1 — 1\frac{3}{16}$	$\frac{1}{8}$
$1\frac{1}{4} — 1\frac{5}{8}$	$\frac{3}{16}$

BOLTS FOR BOLTED TILLERS AND QUADRANTS TABLE 50

DIAMETER OF RUDDER HEAD TABLE 44	ONE BOLT EACH SIDE		TWO BOLTS EACH SIDE		FOUR BOLTS EACH SIDE			THICKNESS OF COUPLING
	Diameter	Distance centre to centre	Diameter	Distance centre to centre	Diameter	Inner bolts centre to centre	Outer bolts centre to centre	
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
3½	1½	11	1¼	10	¾	8½	13½	1
4	1¾	12	1⅜	11	⅞	9½	15	1½
4½	2	13	1½	12	1	10½	16½	1⅝
5	2¼	14	1¾	13	1⅛	11½	18	1¾
5½	2½	15	1⅞	14	1¼	12½	20	1⅞
6	2¾	16½	2	15	1⅜	13½	22	2
6½	3	18	2⅛	16	1½	15	24	2
7	3¼	19	2¼	17	1⅝	16	25½	2¼
7½	3½	20½	2½	18½	1¾	17	27½	2¼
8	3¾	22	2⅝	20	1⅞	18½	29½	2½
8½	3⅞	23	2¾	21	2	19½	31½	2½
9	4	24	2⅞	22	2⅛	20½	33½	2¾
9½			3	23½	2⅛	21½	34½	2¾
10			3¼	24½	2¼	22½	36	3
10½			3⅜	26	2⅜	24	38	3
11			3⅝	27	2½	25	40	3
11½			3¾	28½	2⅝	26	42	3
12			3⅞	29½	2¾	27	43½	3¼
13			4¼	32	3	29½	47½	3¼
14			4½	34½	3⅛	32	51	3¼
15			4⅞	37	3⅜	34	54	3¼

TABLE 51 MASTS AND DERRICK POSTS

DIAMETER AND THICKNESS AT DECK

STAYED

LENGTH OF MAST OR POST	NO DERRICKS	WORKING LOAD OF DERRICKS	
		4 TONS	8 TONS
Feet	Inches	Inches	Inches
30	12 × ·24	18 × ·30	20 × ·30
35	14 × ·26	20 × ·30	22 × ·32
40	16 × ·28	22 × ·30	24 × ·34
45	18 × ·30	23 × ·32	25 × ·36
50	20 × ·32	24 × ·34	26 × ·38
55	22 × ·34	26 × ·38	28 × ·40
60	24 × ·36	28 × ·40	30 × ·42

UNSTAYED

LENGTH OF MAST OR POST	WORKING LOAD OF DERRICKS	
	4 TONS	8 TONS
Feet	Inches	Inches
20	24 × ·36	24 × ·60
25	26 × ·38	26 × ·66
30	28 × ·40	28 × ·72
35	30 × ·40	30 × ·72

NOTES.—TABLE 51

1. Length of mast or derrick post is to be measured from deck to hounds. Tops of small mast houses and derrick plates are not to be regarded as the deck for this purpose, unless the structure is adequately strengthened.

2. Working load of derricks is defined in D 2801 to D 2802.

3. The diameter and thickness of masts and derrick posts at the hounds are to be 85 per cent of the scantlings at the deck.

A

DIAMETER AND SPACING OF RIVETS AND BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

THICKNESS OF PLATES:—	Inches Not exceeding ·36	Inches above ·36 and not exceeding ·50	Inches above ·50 and not exceeding ·72	Inches above ·72 and not exceeding ·94	Inches above ·94 and not exceeding 1·14	Inches above 1·14 and not exceeding 1·26
DIAMETER OF RIVETS:—	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$
SPACING IN DIAMETERS.	SPACING IN INCHES					
$3\frac{1}{2}$	$2\frac{1}{4}$	$2\frac{5}{8}$	$3\frac{1}{8}$	$3\frac{1}{2}$	4	$4\frac{3}{8}$
4	$2\frac{1}{2}$	3	$3\frac{1}{2}$	4	$4\frac{1}{2}$	5
$4\frac{1}{2}$	$2\frac{3}{4}$	$3\frac{3}{8}$	4	$4\frac{1}{2}$	5	$5\frac{5}{8}$
5	$3\frac{1}{8}$	$3\frac{3}{4}$	$4\frac{3}{8}$	5	$5\frac{5}{8}$	$6\frac{1}{4}$
$5\frac{1}{2}$	$3\frac{1}{2}$	$4\frac{1}{8}$	$4\frac{7}{8}$	$5\frac{1}{2}$	$6\frac{1}{8}$	—
6	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	—
$6\frac{1}{2}$	4	$4\frac{7}{8}$	$5\frac{3}{4}$	$6\frac{1}{2}$	—	—
7	$4\frac{1}{2}$	$5\frac{1}{4}$	$6\frac{1}{8}$	7	—	—

BREADTHS OF END LAPS, BUTT STRAPS AND SEAMS

		Inches	Inches	Inches	Inches	Inches	Inches
END LAPS	Single riveted ...	$2\frac{1}{2}$	3	—	—	—	—
	Double riveted ...	$4\frac{1}{4}$	5	6	—	—	—
	Treble riveted ...	6	$7\frac{1}{2}$	9	$10\frac{1}{2}$	12	$13\frac{1}{2}$
	Quadruple riveted ...	—	—	12	14	16	18
	Quintuple riveted ...	—	—	15	$17\frac{1}{2}$	20	$22\frac{1}{2}$
BUTT STRAPS*	Single riveted ...	$4\frac{1}{2}$	$5\frac{1}{4}$	—	—	—	—
	Double riveted ...	8	$9\frac{3}{4}$	$11\frac{1}{4}$	—	—	—
	Treble riveted ...	—	$14\frac{1}{4}$	$16\frac{3}{4}$	19	$21\frac{1}{2}$	24
	Quadruple riveted ...	—	—	22	25	$28\frac{1}{4}$	$31\frac{1}{2}$
SEAMS	Single riveted ...	$2\frac{1}{4}$	$2\frac{1}{2}$	3	$3\frac{1}{2}$	—	—
	Double riveted ...	$3\frac{3}{4}$	$4\frac{1}{2}$	$5\frac{1}{4}$	6	$6\frac{3}{4}$	$7\frac{1}{2}$
	Treble riveted ...	—	—	—	$8\frac{1}{2}$	$9\frac{1}{2}$	$10\frac{1}{2}$

* Single butt straps are to be 25 per cent thicker than the plates to be connected. Where double butt straps are fitted the thickness of the countersunk strap is to be 70 per cent and the thickness of the strap on the opposite side is to be 60 per cent of the thickness of the plates to be connected.

NOTES.—TABLE 52 A

1. The diameter of rivets in seams of keel, sheerstrake, deckstringer, middle line strake of inner bottom and margin plate is to be regulated by the thickness of the adjacent plating.

2. Rivets are to be kept sufficiently clear of edges of plating and of each other, and the distance from the centre of rivet holes to the edges of the plating, end laps or butt straps is not to be less than one and a half rivet diameters.

3. The distance between the centres of consecutive rows of rivets is to be three and a half diameters in end laps, three diameters in butt straps and two and a half diameters in seams.

TABLE 52 B

RIVETING AND WELDING

B

END LAPS AND SEAMS OF SHELL PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth. End laps	Breadth. Butt strap	Spacing of rivets centre to centre	Type of seam	Breadth
	Inches	Inches	Inches		Inches	Inches	Inches		Inches
Sheerstrake for ·4L amidships. *See* Note 4. Bottom plating from keel to upper turn of bilge for ·4L amidships. Keel plates. *See* Note 4. Boss plates.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·84	1	Quadruple	14	25	4	Double	6
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$	Double	6
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5	Double	$6\frac{3}{4}$
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$		
Sheerstrake at ends. Bottom plating from keel to upper turn of bilge at ends.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·94	1	Quadruple	14	25	4	Double	6
Side plating from upper turn of bilge to sheerstrake.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·84	1	Quadruple	14	25	4	Double	6
	·84	·94	1	Quadruple	14	25	4	Treble	$8\frac{1}{2}$
	·94	1·04	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	$4\frac{1}{2}$	Treble	$9\frac{1}{2}$

NOTES.—TABLE 52 B

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. The number of rows of rivets in seams all fore and aft is to be regulated by the thickness of plating amidships. (Except as covered by notes 7 and 8.)

3. Seams of side plating in all ships exceeding 275 feet in length are to be not less than double riveted. (Except as covered by note 8.)

4. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating. (Except as covered by note 8.)

5. For number of rivets between frames in seams of shell plating *see* Table 52 E. Where the form of the ship, forward and aft, is curved the spacing of the rivets is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 500 feet *see* note 7.) Where longitudinal framing is adopted the spacing of rivets in seams of shell plating is not to exceed $4\frac{1}{2}$ diameters, or 4 diameters in way of the strengthening of bottom forward.

6. For riveting in way of strengthening of bottom forward *see* D 808. For riveting in oil fuel bunkers *see* Table 52 H. For riveting in way of strengthening for navigation in ice *see* D 1004, D 1012 and D 1020.

7. In ships above 500 feet in length in the three seams nearest to the neutral axis and for one-fourth of the ship's length in the forward and after bodies the following additions are to be made :—

Above 500 feet and not exceeding 525 feet an additional pair of rivets is to be fitted in each frame space.

Above 525 feet and not exceeding 550 feet two additional pairs of rivets are to be fitted in each frame space.

Above 550 feet and not exceeding 600 feet one seam, and in ships exceeding 600 feet two seams, are to be treble riveted, two additional pairs of rivets being fitted in each frame space in the other seam or seams.

In all the above ships one additional pair of rivets only need be fitted in way of 27 inch frame spacing.

8. In ships where the draught does not exceed ·7D (D being measured to the uppermost continuous deck) and the riveting required by Table 19 for the strength deck stringer angle is single, the lower edge of the sheerstrake may also be single riveted.

9. Seams of long bridges may be single riveted where the riveting required by Table 19 is single but are to be double riveted for four frame spaces at the ends.

10. Seams of poops, short bridges and forecastles may be single riveted.

11. In single riveted seams the rivet is to pass through the frame. In double riveted seams one frame rivet (that adjacent to the caulking edge) is to pass through the seams at each frame except where the frames or edges of the plating are joggled when both rivets are to pass through the frame. In treble riveted seams two frame rivets, the upper and the lower, are to pass through the seams at each frame.

END LAPS AND SEAMS OF DECK PLATING

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Inches	Inches	Inches		Inches	Inches	Inches		Inches.
Strength deck stringer plates for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	*See* note 2	
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3		
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$		
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$		
	·72	·84	1	Quadruple	14	25	4		
	·84	·94	1	Quintuple	$17\frac{1}{2}$		$4\frac{1}{2}$		
	·94	1·14	$1\frac{1}{8}$	Quintuple	20		5		
	1·14	1·26	$1\frac{1}{4}$	Quintuple	$22\frac{1}{2}$		$5\frac{5}{8}$		
Strength deck stringer plates at ends. Lower deck stringer plates. Deck tie plates.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{3}{4}$	*See* note 2	
	·36	·42	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$		
	·42	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$		
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4		
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	4		
	·72	·94	1	Quadruple	14	25	$4\frac{1}{2}$		
	·94	1·14	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	5		
	1·14	1·26	$1\frac{1}{4}$	Quadruple	18	$31\frac{1}{2}$	$5\frac{5}{8}$		
Strength deck plating for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Single	$2\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Single	3
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Single	3
	·72	·76	1	Quadruple	14	25	4	Single	$3\frac{1}{2}$
	·76	·94	1	Quadruple	14	25	4	Double	6
	·94	1·14	$1\frac{1}{8}$	Quadruple	16	$28\frac{1}{4}$	$4\frac{1}{2}$	Double	$6\frac{3}{4}$
Lower deck plating for ·4L amidships.		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{3}{4}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Single	3
Deck plating at ends.		·36	$\frac{5}{8}$	Single	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{3}{4}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Single	3	$5\frac{1}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·42	·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	$3\frac{3}{8}$	Single	$2\frac{1}{2}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	4	Single	3
	·54	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	4	Single	3

NOTES.—TABLE 52 C

1. Treble riveted double butt straps may be fitted as an alternative to quintuple riveted end laps.

2. In seams of stringer plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent deck plating.

3. For number of rivets between beams in seams of deck plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship, and in seams over deep tanks and oil cargo tanks, is not to exceed $4\frac{1}{2}$ diameters. Where longitudinal framing is adopted the spacing of rivets in seams of deck plating is not to exceed $4\frac{1}{2}$ diameters.

4. Where the riveting is not otherwise required to be increased the seams and butts of deck plating over oil fuel bunkers may be single riveted if not more than 28 feet below the top of the overflow; elsewhere the riveting is to be double.

5. For riveting of stringer angles on strength decks *see* Table 19. For riveting of stringer angles on lower decks *see* Table 52 F.

6. Butts of deck plating within line of openings need only be single riveted.

D
END LAPS AND SEAMS OF DOUBLE BOTTOMS

ITEM	THICKNESS		END LAPS AND BUTT STRAPS					SEAMS	
	Above	Not exceeding	Diameter of rivets	Type of end lap and single butt strap	Breadth		Spacing of rivets centre to centre	Type of seam	Breadth
					End laps	Butt strap			
	Inches	Inches	Inches		Inches	Inches	Inches		Inches
Inner bottom middle line strake. Inner bottom plating for ·4L amidships. Margin plates. Centre and side girders (butts).		·36	$\frac{5}{8}$	Double	$4\frac{1}{4}$	8	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Treble	$7\frac{1}{2}$	$14\frac{1}{4}$	3	Double	$4\frac{1}{2}$
	·50	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·68	·72	$\frac{7}{8}$	Quadruple	12	22	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·72	·94	1	Quadruple	14	25	4		
Inner bottom plating at ends.		·36	$\frac{5}{8}$	Single	$2\frac{1}{2}$	$4\frac{1}{2}$	$2\frac{1}{2}$	Single	$2\frac{1}{4}$
	·36	·42	$\frac{3}{4}$	Single	3	$5\frac{1}{4}$	3	Single	$2\frac{1}{2}$
	·42	·48	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Single	$2\frac{1}{2}$
	·48	·50	$\frac{3}{4}$	Double	5	$9\frac{3}{4}$	3	Double	$4\frac{1}{2}$
	·50	·54	$\frac{7}{8}$	Double	6	$11\frac{1}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$
	·54	·68	$\frac{7}{8}$	Treble	9	$16\frac{3}{4}$	$3\frac{1}{2}$	Double	$5\frac{1}{4}$

NOTES.—TABLE 52 D

1. In seams of middle line strake of inner bottom and margin plates the diameter of rivets and type of seam are to be regulated by the thickness of the adjacent inner bottom plating.

2. Where oil fuel is carried in the double bottom and ceiling is not fitted completely over the inner bottom the seams and end laps are to be not less than double riveted.

3. For number of rivets between frames in seams of inner bottom plating *see* Table 52 E. The spacing of rivets in seams not parallel with the middle line of the ship is not to exceed 4 diameters. Where longitudinal framing is adopted the spacing of rivets in seams of inner bottom plating is not to exceed 4 diameters.

E

NUMBER OF RIVETS IN SEAMS OF PLATING BETWEEN FRAMES AND BEAMS EXCLUDING RIVETS IN FRAMES AND BEAMS

FRAME OR BEAM SPACING	THICKNESS OF SHELL AND DECK PLATING IN INCHES						THICKNESS OF INNER BOTTOM PLATING IN INCHES		
	Not exceeding ·36	Above ·36 and not exceeding ·50	Above ·50 and not exceeding ·72	Above ·72 and not exceeding ·94	Above ·94 and not exceeding 1·14	Above 1·14 and not exceeding 1·26	Not exceeding ·36	Above ·36 and not exceeding ·50	Above ·50 and not exceeding ·72
	DIAMETER OF RIVET IN INCHES						DIAMETER OF RIVET IN INCHES		
	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
INCHES	NUMBER OF RIVETS IN EACH ROW						NUMBER OF RIVETS IN EACH ROW		
20	6	5					7	6	
$20\frac{1}{2}$	7	5					7	6	
21	7	5	5				7	6	5
$21\frac{1}{2}$	7	6	5				7	6	5
22	7	6	5				8	6	5
$22\frac{1}{2}$	7	6	5				8	6	5
23	7	6	5	5			8	7	6
$23\frac{1}{2}$		6	5	5			8	7	6
24		6	5	5			8	7	6
$24\frac{1}{2}$		6	5	5			9	7	6
25		7	6	5			9	7	6
$25\frac{1}{2}$		7	6	5				7	7
26		7	6	5	5			8	7
$26\frac{1}{2}$		7	6	5	5			8	7
27		7	6	5	5			8	7
$27\frac{1}{2}$		7	6	5	5			8	7
28		7	6	5	5	5		8	7
$28\frac{1}{2}$		8	6	6	5	5		8	7
29		8	7	6	5	5			8
$29\frac{1}{2}$		8	7	6	5	5			8
30		8	7	6	5	5			8
$30\frac{1}{2}$		8	7	6	5	5			8
31		9	7	6	5	5			8
$31\frac{1}{2}$			7	6	6	5			8
32			7	6	6	5			8
$32\frac{1}{2}$			7	6	6	5			8
33			8	7	6	5			9
$33\frac{1}{2}$			8	7	6	5			9
34			8	7	6	6			9
$34\frac{1}{2}$			8	7	6	6			9
35			8	7	6	6			9
$35\frac{1}{2}$			8	7	6	6			9
36			8	7	6	6			9

F

NUMBER OF RIVETS BETWEEN FRAMES IN EACH FLANGE OF THE ANGLES CONNECTING STRINGER PLATES TO SHELL AND INTERCOSTAL GIRDERS TO SHELL AND INNER BOTTOM

FRAME SPACING INCHES		DIAMETER OF RIVET IN INCHES			
		$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1
Above	Not exceeding	NUMBER OF RIVETS			
—	24	5	4	4	
24	27	6	5	5	4
27	30	7	6	5	5
30	33		7	6	5
33	36			7	6

For strength deck stringer angles *see* Table 19

G

TYPES OF WELDING

SIZE OF FILLET WELDS

PLATING THICKNESS	BASIC LEG LENGTH
Inches	Inches
·20	·22
·30	·26
·40	·30
·50	·34
·60	·38
·70	·44
·80	·50
·90	·56
1·00	·62

NOTES.—TABLE 52 G

1. **Basic leg length** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of fillet will be specially considered.

2. **Basic leg length** for intermediate thickness to be obtained by direct interpolation.

3. **Leg length for double continuous fillets** is the product of Basic Leg Length and the Weld Factor required by Table 52 H.

4. **Leg length for intermittent fillets** is to be given by the formula

Leg Length = Basic Leg Length × Weld Factor × $\frac{d}{s}$ where s and d are as defined in the sketches below. The length s should not be less than 3 inches and s and d are to be such that the required leg length does not exceed the Basic Leg Length.

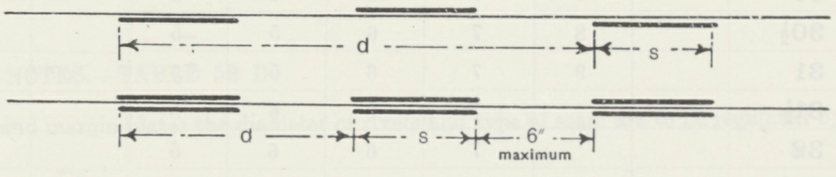
5. **Minimum leg length** of fillet weld to be ·65 of the Basic Leg Length except where a reduction is allowed for flat bar longitudinals. **In no case is the leg length to be less than ·18 inch.**

6. **Throat thickness** of welds is to be 70 per cent of the leg length.

STAGGERED INTERMITTENT

To be doubled at ends. *See* D 3114

CHAIN INTERMITTENT



SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc. WITH DOUBLE FILLET WELDS

Welding to be carried round the ends of all lugs

See also D 3114

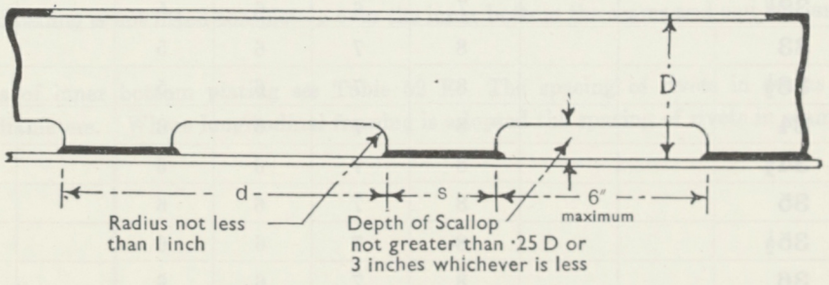


TABLE 52 H

(SEE CONTINUATION)

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to $\frac{7}{8}$ inch in diameter and three and a half times for rivets 1 inch and above in diameter.

The distance from the centre of the rivet hole to the edge of the angle is to be not less than one and a half rivet diameters.

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
TRANSVERSE FRAMING			
Hold frames to shell: Spacing not over 29 inches	7	·21	
Hold frames to shell: over 29 inches and up to 32 inches	$6\frac{1}{2}$	·23	
Hold frames to shell: 32 to 34	6	·25	
Hold frames to shell: 34 and over	$5\frac{1}{2}$	·27	
Hold frames to shell: in deep, oil fuel and peak tanks and in panting region (D 9)	$5\frac{1}{2}$	·27	
Reversed frames to frames	7		
Frames to tank side brackets—spacing not to exceed 7 diameters	See Table 11		
'Tween deck frames to shell	7	·21	
Intermediate frames to shell (D 1004, D 1012 and D 1020)	7	·21	
Bottom frames to shell and floors or floor plates to shell: Spacing not over 32 inches	7	·21	no scallops in way of keel
Bottom frames to shell and floors or floor plates to shell: over 32 inches and up to 34 inches	$6\frac{1}{2}$	·23	no scallops in way of keel
Bottom frames to shell and floors or floor plates to shell: 34 and over	6	·25	no scallops in way of keel
Bottom frames to shell and floors or floor plates to shell: in the forward ·25L	$5\frac{1}{2}$	·27 in peaks; ·54 elsewhere	no scallops in way of keel
Floors and cross ties to frames in fore peak	6	·25	
,, ,, ,, ,, aft ,,	5	·30	
LONGITUDINAL FRAMING			
Bottom frames to shell and floors, or floor plates to shell (*see also* D 519)	5	·30; ·60	no scallops at ends
Bottom longitudinals to shell in the forward ·25L	$5\frac{1}{2}$	·27	
,, ,, ,, ,, remainder	6	·25	
Bottom longitudinals of flatbar type to shell			continuous weld—leg length 30 per cent of thickness of the thinner member being connected
DOUBLE BOTTOMS (Transversely framed)			
Centre girder to keel	5 S.R.	·80	if watertight
,, ,, ,,	$6\frac{1}{2}$ D.R.	·60	elsewhere
,, ,, inner bottom (except in way of centre line bulkhead)	7	·80	if watertight
Centre girder to inner bottom (in way of centre line bulkhead)	5	·50	in engine space and under thrust — no scallops
Centre girder to inner bottom (in way of centre line bulkhead)	5	·43	elsewhere — no scallops
Floors to centre girder	5	·60	under engine, thrust and boiler bearers
Floors to centre girder	5	·30	elsewhere
Floors to intercostal side girders	7	·21	
Intercostal side girder to shell	See Table 52 F	·25	
,, ,, ,, inner bottom under engine and thrust	See Table 52 F	·50	
,, ,, ,, ,, ,, elsewhere	See Table 52 F	·21	
Reversed frames to floors and inner bottom or floor plates to inner bottom	6 D.R.	·50	under engine and thrust
Reversed frames to floors and inner bottom or floor plates to inner bottom	7 S.R.	·21	elsewhere
(For bottom frames to shell and floors or floor plates to shell *see* Transverse Framing above)			
Margin plate to shell	$4\frac{1}{2}$	·80	
Margin connection to tank side brackets and floors	See Table 11	to depend on design	generally 1·00 in panting, ·80 elsewhere
Boundaries of watertight and oiltight floors	5	1·00	
Stiffeners ,, ,, ,,	5	·30	
Riveting and welding in way of heavy oil engines—To be specially considered.			

TABLE 52 H
(SEE CONTINUATION)

RIVETING AND WELDING

H

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
DOUBLE BOTTOMS (Longitudinally framed)			
Longitudinals to inner bottom	6	·25	
Bracket floors and longitudinal framing	See Table 8		
Floors to centre girder (*see also* D 519)	5	·60	no scallops
,, ,, ,, when spacing of floors exceeds 8 feet (*see also* D 519)	5	1·00	
Reversed frames to floors and inner bottom or floor plates to inner bottom (*see also* D 519)	5	·30 ·60	for 2 spaces at ends with one scallop per space
SINGLE BOTTOMS			
Centre keelson to keel	5	·60	no scallops
Reversed frames or face plates to floors	7	·21	
(For bottom frames to shell and floors or floor plates to shell *see* Transverse Framing)			
Floors to centre keelson (double riveted connection where floors cut)	4	1·00	
Foundation plates to reversed frames	4		
Continuous keelson top angles or face plates to vertical keelson plates	7	·21	maximum—one scallop per frame space
Butts of keelsons and foundation plates	4		
Connection of reversed frames to side keelsons—not less than 2 rivets.			
Side keelsons to shell	See Table 52 F	·25	maximum—one scallop per frame space
Riveting or welding in way of machinery—to be specially considered.			
WATERTIGHT BULKHEADS, FLATS AND TUNNELS			
Horizontal connections of plating may be single riveted.			
Vertical connections of plating and boundary angles are to be double riveted when more than 35 feet below the top of the bulkhead.			
Overlaps of plating	4½		
Boundary connections to shell, inner bottom and decks	5	·80	
,, ,, ,, bulkhead	4½	·80	
Stiffeners (except as below)	7	·21	
Stiffeners, lugged or unattached, for 15 per cent of length at each end	4	·38	
Brackets and lugs	See Table 36		
BULKHEADS OF DEEP TANKS, PEAK TANKS AND OIL CARGO TANKS			
Overlaps of plating and boundary angles to be single or double riveted as for watertight bulkheads.			
Overlaps of plating	4		
Stiffeners, bracketed	6	·25	
Boundary connections	As for W.T. bulkheads	1·00 ·80	at bottom and bilge at deck and side
Brackets	See Table 36		

TABLE 52 H

(SEE CONTINUATION)

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
OIL FUEL BUNKERS			
Where not otherwise required to be increased, the overlaps of plating of bulkheads, shell and deck and the stringer angle may be single riveted if not more than 28 feet below the top of the overflow or 16 feet below the top of the tank ; elsewhere the riveting is to be double.			
Centre line bulkheads may be single riveted throughout			
Overlaps of bulkhead, inner bottom and deck plating ...	4		
Deck stringer connection	4	·80	except at strength deck
Boundary connections	5 D.R.	1·00 ·80	at bottom and bilge at deck and side
Stiffeners bracketed	6	·25	
Horizontal girders to shell and bulkheads (*see also* D 2006 to D 2010) ...	4½	·33 ·65	clear of brackets at brackets
Horizontal girders—brackets	4½ D.R.	·65	if overlapped
,, ,, —face angles or plates where area is less than 6 sq. inches	7	·21	
Horizontal girders—face angles or plates where area is more than 6 sq. inches	6	·25	
Stiffener brackets	See Table 36		
NON-WATERTIGHT BULKHEADS			
Overlaps of plating	6		
Boundary connections to inner bottom, horizontal riveted flange (*see also* D 1802)	5	·30	no scallops
Boundary connections elsewhere	7	·21	
Stiffeners	7	·21	
DECKS			
Stringer angle on strength decks	See Table 19		
,, ,, lower ,, ...	,, ,, 52 F		
BEAMS AND DECK LONGITUDINALS			
Beams to deck	7	·21	
,, at crown of deep tanks, peak tanks and oil fuel tanks	6	·25	
Strong beams at ends of hatchways, deck connections (*see also* Deck Girders)	5	·30	
Half beams to hatch coamings and casings—lugs of same thickness as coaming with 2 rivets or 1 sq. inch of welding in each flange for beams not exceeding 8 inches, and 3 rivets or 1·5 sq. inch of welding for beams exceeding 8 inches in depth.			
Longitudinals to deck	6	·25	
Deck longitudinals of flatbar type to deck plating			continuous weld—leg length 30 per cent of thickness of the thinner member being connected
Beam knees	See Table 28		
DECK GIRDERS, TRANSVERSES AND WEBS			
Connections to plating (*see also* D 1505 to D 1508)	5	·30	
Face section, not exceeding 6 sq. inches area, to web	7	·21	
,, ,, exceeding 6 sq. inches area, to web	6	·25	
End brackets	5 D.R.	·80	
Butts of girders	4		

RIVETING AND WELDING

H

DETAILS OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	RIVETED	WELDED	
	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS	WELD FACTOR	NOTES
PILLARS			
Heads and heels of solid pillars	See Table 31		
Seams of tubular pillars	5		
Riveting or welding of pillars built of rolled sections	7	·21	
End connections of widely spaced built pillars	5	·80	
HATCHWAYS			
Coaming to deck	5	·80	
,, ,, at corners	4½	1·00	
Stiffener to coaming	7	·21	
Horizontal stiffeners on coaming where forming watertight recess	5	·80	
Hatch beam angles or face plates	7	·21	
Vertical corner angles	5		
VENTILATORS			
Connection to deck (*see also* D 2403)	4	·80	
DECKHOUSES			
Overlaps of outer casings	5		
,, inner ,,	6		
Foundation connections (*see also* D 1209 and D 1210)	5	·80	
Stiffeners	7	·21	
MASTS			
End laps are to be treble riveted and seams single riveted. Overlaps of plating	5		
RUDDERS			
Spacing of rivets in arms (*see also* D 2618)	4½		
STEMS AND STERNFRAMES			
Connections to shell plating : diameter of rivet with solid sections to be ¼ inch greater than required for the thickness of the plating and ⅛ inch greater for castings or built frames but not to exceed 1⅛ inch	5		
In ships above 350 feet in length shell plating is to be connected to sternframe below the boss by three rows of rivets.			
Connection to transom plate : for ships not exceeding 300 feet in length by two single riveted angles, in ships above 300 feet in length by two double riveted angles	5		

TABLE 53

(SEE CONTINUATION)

EQUIPMENT

Equipment Number (See D 3303 and D 4014)	Equipt. Letter	Stockless Bower Anchors		Stocked Stream Anchor	Stud Link Chain Cable			Stream Wire or Chain			Towline			Mooring Ropes			
		Number	Weight Per Anchor	Weight Ex Stock	Number of 15 Fathom Lengths	Minimum Diameter		Length	Wire Circumference	Short Link Chain dia.	Length	Circumference		Number	Length of Each	Circumference	
						Wrought Iron or Mild Steel	Special Steel (*see notes*)					Wire	Fibre (3 strand)			Wire	Fibre (4 strand)
			Cwt.	Cwt.		Inches	Inches	Fms.	Inches	Inches	Fms.	Inches	Inches		Fms.	Inches	Inches
3000	a	2	4 3/8	3/4	8	1 1/16		45	2	9/16	70	2	5	2	70		3
3600	b	2	5 1/4	1 1/4	8	3/4		45	2 1/4	5/8	70	2	5	2	70		3
4200	c	2	6 1/4	1 3/4	9	1 3/16		50	2 1/4	5/8	80	2 1/4	5	2	80		3
4800	d	2	7 1/8	2 1/4	10	7/8		50	(a) 2 1/2	1 1/16	80	2 1/4	5 1/2	2	80		3
5400	e	2	8 1/8	2 3/4	10	1 5/16		50	2 1/2	1 1/16	80	2 1/4	5 1/2	2	90	1 1/2	3 1/2
6000	f	2	9	3 1/4	11	1		50	2 3/4	3/4	80	2 1/2	5 1/2	2	90	1 1/2	3 1/2
6700	g	3	9 3/4		12	1 1/16	1				80	2 1/2	6	2	90	1 1/2	3 1/2
7400	h	3	11 7/8		13	1 1/8	1 1/16				80	2 3/4	6	2	90	1 3/4	4
8100	i	3	13 7/8		13	1 3/16	1 1/8				90	2 3/4	6 1/2	2	90	1 3/4	4
8900	j	3	16		14	1 1/4	1 1/8				90	3	6 1/2	2	90	1 3/4	4
9700	k	3	18		14	1 5/16	1 1/8				90	3	7	3	90	1 3/4	4
10600	l	3	20 1/8		14	1 3/8	1 3/16				90	3	7	3	90	1 3/4	4
11600	m	3	22 1/4		14	1 7/16	1 1/4				90	(a) 3 1/4	8	3	90	2	4
12700	n	3	24 1/2		14	1 1/2	1 5/16				90	3 1/4	8	3	90	2	4 1/2
13900	o	3	26 3/4		16	1 9/16	1 3/8				100	3 1/2	9	3	90	2 1/4	5
15200	p	3	29		16	1 5/8	1 7/16				100	3 1/2	9	3	90	2 1/4	5 1/2
16800	q	3	31 3/8		16	1 11/16	1 7/16				100	4	9	3	100	2 1/2	5 1/2
18600	r	3	33 7/8		16	1 3/4	1 1/2				100	4	10	3	100	2 1/2	6
20600	s	3	36 7/8		16	1 13/16	1 9/16				100	4		3	100	2 3/4	6
22700	t	3	39 7/8		16	1 7/8	1 5/8				100	4 1/2		3	100	2 3/4	6 1/2
25000	u	3	43 1/4		18	1 15/16	1 11/16				110	4 1/2		3	100	(a) 2 3/4	6 1/2
27300	v	3	46 5/8		18	2	1 3/4				110	4 1/2		4	100	2 3/4	6 1/2
29700	w	3	50		18	2 1/16	1 13/16				110	5		4	100	2 3/4	6 1/2
32200	x	3	53 3/4		18	2 1/8	1 13/16				110	5		4	100	2 3/4	7
34800	y	3	57 1/2		18	2 3/16	1 7/8				110	4 1/2		4	100	3	7
37600	z	3	61 1/2		18	2 1/4	1 15/16				110	4 1/2		4	100	3	7
40400	a†	3	65 1/2		18	2 5/16	2				120	5		4	100	3	7
43200	b†	3	69 1/2		20	2 3/8	2 1/16				120	5		4	100	3 1/4	7
46000	c†	3	73 1/2		20	2 7/16	2 1/8				120	5		4	110	3 1/4	8
48800	d†	3	77 3/4		20	2 1/2	2 3/16				120	5 1/2		4	110	3 1/4	8
51600	e†	3	81 3/4		20	2 9/16	2 1/4				120	5 1/2		4	110	3 1/4	8
54600	f†	3	86		20	2 5/8	2 1/4				120	5 1/2		5	110	3 1/4	8
57600	g†	3	90 1/4		22	2 11/16	2 5/16				130	(b) 6		5	110	3 1/4	8
60600	h†	3	94 1/2		22	2 3/4	2 3/8				130	6		5	110	3	8
63800	i†	3	99		22	2 13/16	2 7/16				130	6 1/2		5	110	3	8
67000	j†	3	103 1/2		22	2 7/8	2 1/2				130	6 1/2		5	110	3	9
70200	k†	3	107 3/4		22	2 15/16	2 9/16				130	6 1/2		5	110	3	9
73400	l†	3	112		22	3	2 5/8				130	7		5	110	3	9
76800	m†	3	116 1/4		22	3 1/16	2 11/16				140	7		5	110	3 1/4	9
80200	n†	3	120 1/2		22	3 1/8	2 3/4				140	7		5	110	3 1/4	9
83800	o†	3	125		22	3 3/16	2 3/4				140	7		5	120	3 1/4	9
87600	p†	3	129 3/4		22	3 1/4	2 13/16				140	7		5	120	3 1/4	9
91600	q†	3	134 3/4		22	3 5/16	2 7/8				140	7		6	120	3 1/4	9
95800	r†	3	140		22	3 3/8	2 15/16				140	7		6	120	3 1/4	9
100200	s†	3	145 1/2		22	3 7/16	3				150	7 1/2		6	120	(b) 3 1/4	9
105000	t†	3	151 1/2		22	3 1/2	3 1/16				150	7 1/2		6	120	3 1/4	9
110000	u†	3	157 1/2		22	3 9/16	3 1/8				150	(c) 7 1/2		6	120	3 1/4	9
115000	v†	3	163 1/2		22	3 5/8	3 3/16				150	7 1/2		6	120	3 1/2	10
120000	w†	3	169 1/2		22	3 11/16	3 1/4				150	8		6	120	3 1/2	10
125000	x†	3	175 1/2		22	3 3/4	3 5/16				150	8		6	120	3 1/2	10
130000	y†	3	181 1/2		22	3 13/16	3 3/8				150	8		6	120	3 1/2	10
135000	z†	3	188		22	3 7/8	3 7/16				150	8		6	120	3 1/2	10

(*a*) = 6 × 12 Flexible Steel Wire Rope. (*b*) = 6 × 24 Flexible Steel Wire Rope. (*c*) = 6 × 37 Special Flexible Steel Wire Rope.

TABLE 53
(CONCLUDED)

Equipment Number (*See* D 3303 and D 4014)	Equipt. Letter	Stockless Bower Anchors		Stocked Stream Anchor	Stud Link Chain Cable			Stream Wire or Chain			Towline			Mooring Ropes			
		Number	Weight Per Anchor	Weight Ex Stock	Number of 15 Fathom Lengths	Minimum Diameter		Length	Wire Circumference	Short Link Chain dia.	Length	Circumference		Number	Length of Each	Circumference	
						Wrought Iron or Mild Steel	Special Steel (*see notes*)					Wire	Fibre (3 strand)			Wire	Fibre (4 strand)
			Cwt.	Cwt.		Inches	Inches	Fms.	Inches	Inches	Fms.	Inches	Inches		Fms.	Inches	Inches
140000	a*	3	194½		24	3 15/16	3½				160	8		6	120	3½	
145000	b*	3	201		24	4	3 9/16				160	8		6	120	3¾	
150000	c*	3	207½		24	4 1/16	3⅝				160	8½		6	120	3¾	
155000	d*	3	214		24	4⅛	3 11/16				160	8½		6	120	3¾	
160000	e*	3	220½		24		3 11/16				160	8½		7	120	3¾	
165000	f*	3	227		24		3¾				160	8½		7	120	3¾	
170000	g*	3	233½		24		3 13/16				160	8½		7	120	3¾	
175000	h*	3	240		24		3⅞				160	8½		7	120	3¾	
180000	i*	3	246½		24		3 15/16				160	8½		7	120	3¾	
185000	j*	3	253		24		4				160	9		7	120	3¾	
190000	k*	3	259½		24		4 1/16				170	9		7	120	4	
195000	l*	3	266		24		4⅛				170	9		7	120	4	
200000	m*	3	272½		24		4 3/16				170	9		7	120	4	
205000	n*	3	279		24		4¼				170	9		7	120	4	
210000	o*	3	285½		24		4 5/16				170	9		7	120	4	
215000	p*	3	292		24		4⅜				170	9		7	120	4	
220000	q*	3	298½		24		4 7/16				170	9		7	120	4	

(*a*) = 6 × 12 Flexible Steel Wire Rope. (*b*) = 6 × 24 Flexible Steel Wire Rope. (*c*) = 6 × 37 Special Flexible Steel Wire Rope.

NOTES. — TABLE 53

1. Where the Equipment Number lies between any two consecutive numbers given in the Table, the equipment is to be governed by the greater.

2. Bower Anchors. The weight per anchor given in the Table is for anchors of equal weight. The weight of individual anchors may vary ± 7 per cent from the Table weight provided the total weight of anchors is not less than would have been required for anchors of equal weight.

3. If it is desired to use stocked bower anchors the weight "ex stock" is to be 80 per cent of the Table weight. For weight of stock *see* D 3304.

4. For special steel cable, see P 1301.

5. The weight of each 15 fathom length of cable, including one joining shackle, is not to be less than that given in P 1305.

6. Steel wire ropes other than those given in the Table may be used if of equivalent strength.

7. Ropes of strength equivalent to the fibre 3-strand and fibre 4-strand given for towline and mooring ropes may be used.

Ropes of synthetic materials will be accepted on the basis of equivalent breaking loads.

8. Tests. *See* P 1104 for anchors.
P 1305 for cables.
P 1406 to P 1408 for wire ropes.
P 1409 for fibre ropes.

TABLE 54 EQUIPMENT FOR TUGS

EQUIPMENT NUMBER	STOCKLESS BOWER ANCHORS		WROUGHT IRON OR MILD STEEL STUD LINK CHAIN CABLE		FIBRE MOORING ROPES (4-strand)		
	Number	Minimum weight of each anchor	Number of 15 fathom lengths	Diameter	Length of each	Circumference	
						First	Second
		Cwt.		Inches	Fathoms	Inches	Inches
1440	2	$3\frac{1}{4}$	4	$\frac{5}{8}$	60	$4\frac{1}{4}$	$2\frac{1}{2}$
1700	2	$3\frac{1}{2}$	4	$\frac{11}{16}$	60	$4\frac{1}{2}$	$2\frac{1}{2}$
1970	2	$3\frac{3}{4}$	4	$\frac{11}{16}$	60	$4\frac{3}{4}$	$2\frac{1}{2}$
2240	2	4	4	$\frac{3}{4}$	60	$4\frac{3}{4}$	$2\frac{1}{2}$
2510	2	$4\frac{1}{4}$	4	$\frac{13}{16}$	60	5	$2\frac{3}{4}$
2780	2	$4\frac{1}{2}$	5	$\frac{13}{16}$	60	5	3
3050	2	$4\frac{3}{4}$	5	$\frac{7}{8}$	60	$5\frac{1}{2}$	$3\frac{1}{4}$
3330	2	5	5	$\frac{7}{8}$	60	$5\frac{1}{2}$	$3\frac{1}{2}$
3620	2	$5\frac{3}{8}$	5	$\frac{15}{16}$	60	$5\frac{1}{2}$	$3\frac{3}{4}$
3910	2	$5\frac{3}{4}$	6	$\frac{15}{16}$	60	$5\frac{1}{2}$	4
4200	2	$6\frac{1}{8}$	6	1	60	6	$4\frac{1}{4}$
4490	2	$6\frac{3}{8}$	6	1	60	6	$4\frac{1}{2}$
4780	2	$6\frac{3}{4}$	7	$1\frac{1}{16}$	60	6	$4\frac{3}{4}$
5080	2	7	7	$1\frac{1}{16}$	60	6	5
5380	2	$7\frac{3}{8}$	7	$1\frac{1}{8}$	60	$6\frac{1}{2}$	5
5690	2	$7\frac{5}{8}$	8	$1\frac{1}{8}$	60	$6\frac{1}{2}$	5
6000	2	8	8	$1\frac{1}{8}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
6310	2	$8\frac{3}{8}$	9	$1\frac{3}{16}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
6620	2	$8\frac{3}{4}$	9	$1\frac{3}{16}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
6940	2	$9\frac{1}{4}$	9	$1\frac{3}{16}$	60	$6\frac{1}{2}$	$5\frac{1}{2}$
7260	2	$9\frac{3}{4}$	10	$1\frac{1}{4}$	60	7	$5\frac{1}{2}$
7590	2	$10\frac{1}{4}$	10	$1\frac{1}{4}$	60	7	$5\frac{1}{2}$
7920	2	$10\frac{3}{4}$	10	$1\frac{1}{4}$	60	7	$5\frac{1}{2}$
8260	2	$11\frac{3}{8}$	11	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
8600	3	12	11	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
8950	3	$12\frac{3}{4}$	12	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
9300	3	$13\frac{1}{2}$	12	$1\frac{5}{16}$	60	7	$5\frac{1}{2}$
9650	3	$14\frac{5}{8}$	12	$1\frac{3}{8}$	60	7	$5\frac{1}{2}$
10000	3	$15\frac{3}{4}$	13	$1\frac{3}{8}$	60	7	$5\frac{1}{2}$
10350	3	$16\frac{7}{8}$	13	$1\frac{3}{8}$	90	7	$5\frac{1}{2}$
10700	3	$18\frac{1}{8}$	14	$1\frac{3}{8}$	90	7	$5\frac{1}{2}$
11050	3	$19\frac{1}{2}$	14	$1\frac{7}{16}$	90	7	$5\frac{1}{2}$

NOTES.—TABLE 54

1. Where the Equipment Number lies between any two consecutive numbers given in the Table the equipment is to be governed by the greater.

2. If it is desired to use stocked anchors the weight "ex stock" is to be 80 per cent of the Table weight. For weight of stock *see* D 3304.

3. If it is desired to use short link chain the diameter is to be that for which the same proof test is required as for the stud link chain given in the Table. *See* P 1305.

4. Tests. *See* P 1104 for anchors.
P 1305 for cables.
P 1406 to P 1408 for wire ropes.
P 1409 for fibre ropes.

RENEWAL OF STEERING CHAINS & CHAIN CABLES WHEN WORN

When any length of a chain is so worn that the mean diameter at its most worn part is reduced to the size given in the following Table it is to be renewed.

ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL	ORIGINAL DIAMETER	MEAN DIAMETER REQUIRING RENEWAL
Inches	Inches	Inches	Inches	Inches	Inches	Inches	Inches
$\frac{3}{8}$	$\frac{11}{32}$	$1\frac{5}{16}$	$1\frac{3}{16}$	$2\frac{1}{4}$	2	$3\frac{3}{16}$	$2\frac{7}{8}$
$\frac{7}{16}$	$\frac{13}{32}$	$1\frac{3}{8}$	$1\frac{7}{32}$	$2\frac{5}{16}$	$2\frac{1}{16}$	$3\frac{1}{4}$	$2\frac{15}{16}$
$\frac{1}{2}$	$\frac{7}{16}$	$1\frac{7}{16}$	$1\frac{9}{32}$	$2\frac{3}{8}$	$2\frac{1}{8}$	$3\frac{5}{16}$	$2\frac{31}{32}$
$\frac{9}{16}$	$\frac{1}{2}$	$1\frac{1}{2}$	$1\frac{11}{32}$	$2\frac{7}{16}$	$2\frac{3}{16}$	$3\frac{3}{8}$	$3\frac{1}{32}$
$\frac{5}{8}$	$\frac{9}{16}$	$1\frac{9}{16}$	$1\frac{13}{32}$	$2\frac{1}{2}$	$2\frac{1}{4}$	$3\frac{7}{16}$	$3\frac{1}{16}$
$\frac{11}{16}$	$\frac{5}{8}$	$1\frac{5}{8}$	$1\frac{15}{32}$	$2\frac{9}{16}$	$2\frac{9}{32}$	$3\frac{1}{2}$	$3\frac{1}{8}$
$\frac{3}{4}$	$\frac{21}{32}$	$1\frac{11}{16}$	$1\frac{1}{2}$	$2\frac{5}{8}$	$2\frac{11}{32}$	$3\frac{9}{16}$	$3\frac{3}{16}$
$\frac{13}{16}$	$\frac{23}{32}$	$1\frac{3}{4}$	$1\frac{9}{16}$	$2\frac{11}{16}$	$2\frac{13}{32}$	$3\frac{5}{8}$	$3\frac{1}{4}$
$\frac{7}{8}$	$\frac{25}{32}$	$1\frac{13}{16}$	$1\frac{5}{8}$	$2\frac{3}{4}$	$2\frac{15}{32}$	$3\frac{11}{16}$	$3\frac{5}{16}$
$\frac{15}{16}$	$\frac{27}{32}$	$1\frac{7}{8}$	$1\frac{11}{16}$	$2\frac{13}{16}$	$2\frac{17}{32}$	$3\frac{3}{4}$	$3\frac{3}{8}$
1	$\frac{29}{32}$	$1\frac{15}{16}$	$1\frac{23}{32}$	$2\frac{7}{8}$	$2\frac{9}{16}$	$3\frac{13}{16}$	$3\frac{7}{16}$
$1\frac{1}{16}$	$\frac{15}{16}$	2	$1\frac{25}{32}$	$2\frac{15}{16}$	$2\frac{5}{8}$	$3\frac{7}{8}$	$3\frac{1}{2}$
$1\frac{1}{8}$	1	$2\frac{1}{16}$	$1\frac{27}{32}$	3	$2\frac{11}{16}$		
$1\frac{3}{16}$	$1\frac{1}{16}$	$2\frac{1}{8}$	$1\frac{29}{32}$	$3\frac{1}{16}$	$2\frac{3}{4}$		
$1\frac{1}{4}$	$1\frac{1}{8}$	$2\frac{3}{16}$	$1\frac{31}{32}$	$3\frac{1}{8}$	$2\frac{13}{16}$		

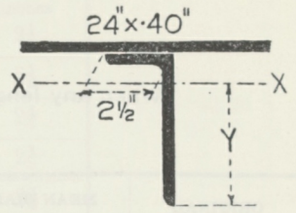
TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

ANGLES HAVING $2\frac{1}{2}$-in. FLANGE

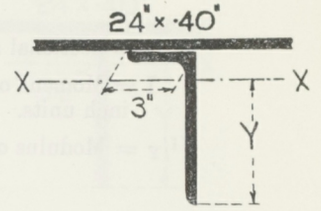


DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·20	·22	·24	·26	·28	·30	·32	·34	·36	·38	·40
$2\frac{1}{2}$	A	·96	1·05	1·14	1·23	1·32	1·41	1·50	1·58	1·67	1·76	1·84
	I	1·20	1·32	1·44	1·56	1·68	1·80	1·92	2·05	2·18	2·30	2·43
	$I/_Y$	·46	·50	·55	·60	·65	·70	·75	·80	·85	·90	·96
3	A	1·06	1·16	1·26	1·36	1·46	1·56	1·66	1·75	1·85	1·95	2·04
	I	2·03	2·26	2·49	2·60	2·80	3·00	3·20	3·40	3·60	3·80	4·00
	$I/_Y$	·66	·72	·78	·85	·92	·99	1·06	1·13	1·20	1·27	1·33
$3\frac{1}{2}$	A		1·27	1·38	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24
	I		3·40	3·70	3·95	4·20	4·50	4·80	5·10	5·38	5·66	5·94
	$I/_Y$		·96	1·04	1·13	1·21	1·30	1·38	1·47	1·55	1·63	1·72

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·42	·44	·46	·48	·50	·52	·54	·56	·58	·60	·62
$2\frac{1}{2}$	A	1·92	2·01	2·09	2·17	2·25	2·33	2·41				
	I	2·56	2·68	2·80	2·92	3·04	3·15	3·26				
	$I/_Y$	1·01	1·06	1·11	1·16	1·21	1·26	1·30				
3	A	2·13	2·23	2·32	2·41	2·50	2·59	2·68	2·77	2·85		
	I	4·20	4·40	4·59	4·75	4·90	5·05	5·21	5·36	5·51		
	$I/_Y$	1·39	1·45	1·51	1·59	1·63	1·69	1·76	1·83	1·90		
$3\frac{1}{2}$	A	2·34	2·45	2·55	2·65	2·75	2·85	2·95	3·05	3·14	3·24	
	I	6·22	6·50	6·78	7·05	7·32	7·56	7·80	8·10	8·40	8·60	
	$I/_Y$	1·81	1·90	1·99	2·07	2·16	2·24	2·32	2·41	2·50	2·58	

GEOMETRICAL PROPERTIES OF SECTIONS

ANGLES HAVING 3-in. FLANGE



A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46
3	A	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24	2·34	2·45	2·55
	I	2·60	2·80	3·00	3·20	3·40	3·60	3·80	4·00	4·20	4·40	4·60
	$I/_Y$	·85	·92	·99	1·06	1·13	1·20	1·27	1·33	1·39	1·45	1·51
$3\frac{1}{2}$	A	1·62	1·74	1·86	1·98	2·09	2·21	2·33	2·44	2·55	2·67	2·78
	I	4·00	4·20	4·50	4·80	5·10	5·40	5·70	6·00	6·30	6·60	6·90
	$I/_Y$	1·14	1·22	1·30	1·38	1·47	1·56	1·65	1·73	1·82	1·92	2·02
4	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01
	I	5·80	6·20	6·60	7·00	7·40	7·80	8·20	8·60	9·00	9·40	9·80
	$I/_Y$	1·45	1·56	1·67	1·78	1·89	2·00	2·10	2·20	2·30	2·40	2·52
5	A	2·01	2·16	2·31	2·46	2·60	2·75	2·90	3·04	3·18	3·33	3·47
	I	9·75	11·00	12·25	13·00	13·75	14·50	15·20	15·90	16·60	17·30	18·00
	$I/_Y$	2·00	2·27	2·55	2·70	2·86	3·01	3·16	3·32	3·48	3·64	3·80
6	A	2·27	2·44	2·61	2·78	2·94	3·11	3·28	3·44	3·60	3·77	3·93
	I	18·70	19·90	21·00	22·10	23·20	24·30	25·40	26·50	27·60	28·70	29·80
	$I/_Y$	3·26	3·47	3·68	3·89	4·09	4·31	4·53	4·75	4·98	5·20	5·42

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·48	·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70
3	A	2·65	2·75	2·85	2·95	3·05	3·14						
	I	4·80	4·90	5·10	5·25	5·40	5·60						
	$I/_Y$	1·59	1·63	1·69	1·76	1·83	1·90						
$3\frac{1}{2}$	A	2·89	3·00	3·11	3·22	3·33	3·43	3·54					
	I	7·20	7·40	7·60	7·80	8·20	8·40	8·60					
	$I/_Y$	2·10	2·17	2·24	2·32	2·41	2·50	2·58					
4	A	3·13	3·25	3·37	3·49	3·61	3·72	3·84	3·96				
	I	10·20	10·50	10·90	11·30	11·70	12·00	12·30	12·60				
	$I/_Y$	2·63	2·74	2·85	2·96	3·07	3·17	3·28	3·39				
5	A	3·61	3·75	3·89	4·03	4·17	4·30	4·44	4·58	4·71	4·84		
	I	18·70	19·30	20·00	20·70	21·30	22·00	22·70	23·30	24·00	24·60		
	$I/_Y$	3·96	4·12	4·28	4·45	4·61	4·77	4·93	5·09	5·25	5·41		
6	A	4·09	4·25	4·41	4·57	4·73	4·88	5·04	5·20	5·35	5·50	5·66	5·81
	I	30·90	32·00	33·10	34·20	35·30	36·40	37·40	38·40	39·40	40·40	41·40	42·40
	$I/_Y$	5·63	5·86	6·08	6·30	6·51	6·72	6·94	7·16	7·38	7·60	7·81	8·03

TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

ANGLES HAVIN

A = Sectional area of angle in square inches.

I = Moment of inertia about neutral axis XX in inch units.

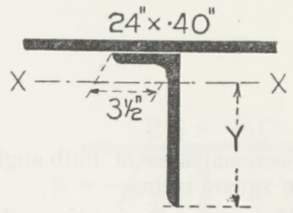
$I/_Y$ = Modulus of resistance of section in inch units.

} In conjunction with plating.

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
$3\frac{1}{2}$	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01	3·13
	I	3·7	4·0	4·3	4·6	4·9	5·1	5·3	5·6	5·9	6·2	6·5	6·8
	$I/_Y$	1·04	1·13	1·22	1·31	1·40	1·48	1·56	1·65	1·73	1·82	1·91	2·00
4	A	1·88	2·02	2·16	2·30	2·43	2·57	2·71	2·84	2·97	3·11	3·24	3·37
	I	6·0	6·3	6·7	7·0	7·4	7·8	8·2	8·6	9·0	9·4	9·8	10·2
	$I/_Y$	1·46	1·56	1·66	1·76	1·87	1·98	2·09	2·20	2·30	2·41	2·52	2·63
5	A	2·14	2·30	2·46	2·62	2·77	2·93	3·09	3·24	3·39	3·55	3·70	3·85
	I	10·6	11·4	12·2	13·0	13·7	14·4	15·1	15·8	16·5	17·2	18·0	18·7
	$I/_Y$	2·25	2·40	2·55	2·70	2·87	3·03	3·19	3·35	3·51	3·68	3·84	4·00
6	A			2·76	2·94	3·11	3·29	3·47	3·64	3·81	3·99	4·16	4·33
	I			20·4	21·6	22·8	24·0	25·2	26·4	27·6	28·8	29·9	31·0
	$I/_Y$			3·58	3·82	4·04	4·27	4·50	4·72	4·95	5·18	5·40	5·62
7	A					3·45	3·65	3·85	4·04	4·23	4·43	4·62	4·81
	I					35·5	37·2	38·9	40·6	42·3	44·0	45·7	47·4
	$I/_Y$					5·44	5·74	6·04	6·34	6·64	6·94	7·24	7·53

GEOMETRICAL PROPERTIES OF SECTIONS

3½-in. FLANGE



THICKNESS OF WEB IN INCHES												ITEM	DEPTH OF WEB IN INCHES
·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74		
3·25	3·37	3·49	3·61	3·72	3·84	3·96	4·07						A	3½
7·1	7·3	7·6	7·9	8·1	8·4	8·7	9·0						I	
2·09	2·18	2·26	2·34	2·42	2·50	2·59	2·70						$I/_Y$	
3·50	3·63	3·76	3·89	4·01	4·14	4·27	4·39	4·51					A	4
10·6	10·9	11·2	11·6	12·0	12·3	12·6	13·0	13·4					I	
2·74	2·85	2·95	3·06	3·17	3·28	3·39	3·50	3·61					$I/_Y$	
4·00	4·15	4·30	4·45	4·59	4·74	4·89	5·03	5·17	5·32	5·46			A	5
19·4	20·0	20·6	21·3	22·0	22·6	23·2	23·8	24·4	25·0	25·6			I	
4·15	4·32	4·48	4·64	4·80	4·95	5·12	5·28	5·44	5·60	5·68			$I/_Y$	
4·50	4·67	4·84	5·01	5·17	5·34	5·51	5·67	5·83	6·00	6·16	6·32	6·48	A	6
32·1	33·2	34·2	35·3	36·3	37·4	38·4	39·4	40·4	41·4	42·3	43·2	44·1	I	
5·84	6·06	6·28	6·50	6·72	6·94	7·16	7·38	7·60	7·82	8·04	8·25	8·46	$I/_Y$	
5·00	5·19	5·38	5·57	5·75	5·94	6·13	6·31	6·49	6·68	6·86	7·04	7·22	A	7
49·1	50·7	52·3	53·9	55·5	57·0	58·5	60·0	61·5	63·0	64·5	65·9	67·2	I	
7·82	8·11	8·40	8·69	8·98	9·26	9·55	9·84	10·13	10·41	10·70	10·98	11·25	$I/_Y$	

TABLE 56

(*SEE CONTINUATION*)

GEOMETRICAL PROPERTIES OF SECTIONS

BULB ANGLE

A = Sectional area of bulb angles in square inches.

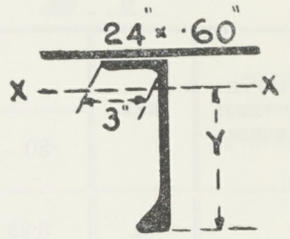
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.

$I/_Y$ = Modulus of resistance of section in inch units. }

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES										
		·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
5	A	2·52	2·66	2·79	2·92	3·06	3·19	3·32	3·45	3·59	3·72	3·85
	I	19·8	20·7	21·5	22·4	23·4	24·4	25·3	26·3	27·3	28·3	29·3
	$I/_Y$	4·00	4·20	4·40	4·55	4·75	4·95	5·15	5·35	5·55	5·75	6·00
5½	A		2·88	3·02	3·16	3·31	3·45	3·59	3·72	3·86	4·00	4·15
	I		27·7	28·8	29·9	31·0	32·2	33·4	34·5	35·7	36·9	38·1
	$I/_Y$		5·15	5·40	5·60	5·80	6·05	6·25	6·50	6·70	6·95	7·20
6	A		3·12	3·27	3·42	3·58	3·73	3·88	4·03	4·18	4·33	4·48
	I		36·1	37·5	39·0	40·5	42·1	43·7	45·3	46·8	48·3	49·8
	$I/_Y$		6·25	6·50	6·80	7·10	7·35	7·65	7·90	8·20	8·45	8·75
7	A				3·96	4·13	4·30	4·47	4·64	4·81	4·99	5·16
	I				62·7	64·7	66·7	68·8	70·9	73·0	75·2	77·5
	$I/_Y$				9·60	9·95	10·25	10·60	10·95	11·30	11·65	12·05
8	A					4·68	4·88	5·07	5·26	5·45	5·64	5·83
	I					97·7	100·5	103·4	106·5	109·6	112·6	115·8
	$I/_Y$					13·45	13·85	14·30	14·75	15·20	15·65	16·10

GEOMETRICAL PROPERTIES OF SECTIONS

HAVING 3-in. FLANGE



THICKNESS OF WEB IN INCHES											ITEM	DEPTH OF WEB IN INCHES
·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70		
3·99 30·2 6·20	4·12 31·2 6·40	4·25 32·2 6·60	4·38 33·1 6·80								A I I/Y	5
4·29 39·4 7·45	4·43 40·6 7·70	4·57 41·9 7·95	4·71 43·4 8·20								A I I/Y	5½
4·63 51·2 9·00	4·78 52·8 9·30	4·94 54·3 9·60	5·09 55·8 9·85	5·24 57·2 10·10							A I I/Y	6
5·33 79·8 12·40	5·50 82·0 12·80	5·67 84·2 13·15	5·84 86·4 13·50	6·02 88·5 13·85	6·19 90·6 14·20						A I I/Y	7
6·02 119·0 16·60	6·21 122·0 17·10	6·40 125·0 17·55	6·60 128·0 18·00	6·79 130·9 18·45	6·98 133·7 18·90	7·17 136·5 19·30					A I I/Y	8

TABLE 56
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

BULB ANGLE

A = Sectional area of bulb angles in square inches.
I = Moment of inertia about neutral axis X X in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50	·52	·54
6	A	3·29	3·45	3·60	3·76	3·98	4·07	4·23	4·39	4·55	4·70	4·86	5·02	5·18
	I	36·5	37·9	39·3	40·8	42·3	43·8	45·4	46·9	48·4	49·9	51·4	52·9	54·4
	$I/_Y$	6·35	6·60	6·85	7·10	7·40	7·65	7·95	8·20	8·50	8·80	9·05	9·35	9·65
7	A			4·15	4·32	4·50	4·68	4·86	5·03	5·21	5·39	5·56	5·74	5·92
	I			62·8	64·9	66·9	69·0	71·1	73·2	75·4	77·7	80·0	82·3	84·6
	$I/_Y$			9·65	9·95	10·25	10·60	10·95	11·30	11·65	12·05	12·45	12·80	13·20
8	A				4·89	5·08	5·28	5·47	5·67	5·86	6·05	6·25	6·44	6·64
	I				98·0	100·9	103·9	107·0	110·1	113·2	116·4	119·5	122·5	125·4
	$I/_Y$				13·45	13·85	14·35	14·80	15·25	15·75	16·20	16·70	17·15	17·60
9	A					5·70	5·92	6·13	6·35	6·57	6·78	7·00	7·22	7·43
	I					148·0	151·5	155·0	159·0	163·0	167·0	171·0	175·0	179·0
	$I/_Y$					18·40	18·90	19·40	19·90	20·50	21·05	21·60	22·20	22·70
10	A						6·57	6·80	7·04	7·28	7·51	7·75	7·98	8·22
	I						211·0	215·5	220·5	225·5	230·5	235·5	240·5	246·0
	$I/_Y$						24·20	24·80	25·45	26·10	26·80	27·40	28·10	28·80
11	A							7·50	7·76	8·02	8·28	8·53	8·79	9·05
	I							286·4	292·0	298·1	304·2	310·3	316·6	323·2
	$I/_Y$							30·80	31·55	32·30	33·05	33·80	34·55	35·40
12	A								8·50	8·77	9·05	9·33	9·61	9·89
	I								382·0	389·0	396·1	403·8	411·5	419·5
	$I/_Y$								38·65	39·45	40·30	41·20	42·10	43·05

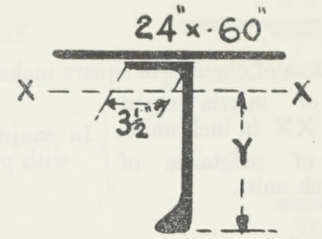
BULB ANGLE

$13\frac{1}{2}$	A									10·22	10·54	10·84	11·15	11·47
	I									564·6	572·0	580·0	588·8	598·4
	$I/_Y$									52·40	53·30	54·20	55·25	56·30

GEOMETRICAL PROPERTIES OF SECTIONS

TABLE 56
(SEE CONTINUATION)

HAVING $3\frac{1}{2}$-in. FLANGE



THICKNESS OF WEB IN INCHES											ITEM	DEPTH OF WEB IN INCHES
·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78		
5·34	5·49	5·65	5·81									A	6
55·9	57·3	58·7	60·0									I	
9·90	10·15	10·40	10·65									I/Y	
6·09	6·27	6·45	6·62	6·80								A	7
86·8	88·9	91·0	93·2	95·3								I	
13·55	13·95	14·30	14·65	15·00								I/Y	
6·83	7·03	7·23	7·42	7·62	7·81							A	8
128·3	131·1	133·9	136·8	139·6	142·4							I	
18·05	18·50	18·90	19·35	19·75	20·20							I/Y	
7·65	7·87	8·08	8·30	8·52	8·73	8·95						A	9
183·0	187·0	191·0	195·0	199·0	203·0	207·0						I	
23·30	23·85	24·45	25·00	25·6	26·15	26·70						I/Y	
8·46	8·69	8·92	9·16	9·40	9·64	9·88	10·12	10·35				A	10
251·0	256·0	261·0	266·0	271·0	276·0	281·0	286·0	291·0				I	
29·45	30·10	30·80	31·45	32·10	32·80	33·50	34·20	34·80				I/Y	
9·31	9·56	9·82	10·07	10·33	10·59	10·84	11·09	11·35	11·60			A	11
329·7	336·2	342·6	349·0	355·3	361·4	367·5	373·4	379·3	385·0			I	
36·20	37·00	37·80	38·60	39·40	40·20	40·95	41·70	42·45	43·20			I/Y	
10·17	10·44	10·72	10·99	11·27	11·55	11·83	12·10	12·38	12·65	12·93		A	12
427·5	435·5	443·5	451·2	458·9	466·4	473·7	481·0	488·2	495·1	501·9		I	
44·00	44·95	45·90	46·85	47·75	48·65	49·55	50·45	51·30	52·15	53·00		I/Y	

HAVING 4-in. FLANGE

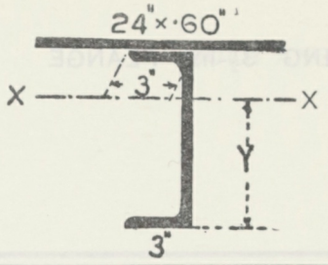
11·78	12·09	12·41	12·72	13·03	13·34	13·65	13·96	14·28	14·59	14·90	15·21	A	$13\frac{1}{2}$
608·5	618·5	628·5	639·0	650·0	660·5	671·0	681·0	691·0	701·0	710·5	720·0	I	
57·40	58·50	59·60	60·80	61·95	63·15	64·30	64·65	66·50	67·60	68·70	69·80	I/Y	

TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

CHANNELS HAVING 3-in. FLANGE



A = Sectional area of channel in square inches.

I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.

$I/_Y$ = Modulus of resistance of section in inch units. }

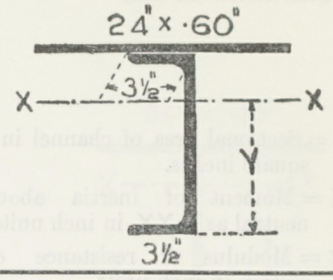
DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
			·24	·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
6	·38	A	3·59	3·71	3·83	3·95	4·07	4·19	4·31	4·43	4·55	4·67	4·79	4·91	5·03
		I	52·4	53·6	54·8	55·9	57·1	58·3	59·4	60·5	61·6	62·7	63·8	64·9	66·0
		$I/_Y$	9·25	9·50	9·75	10·0	10·25	10·5	10·75	10·95	11·2	11·4	11·65	11·9	12·1
7	·42	A		4·18	4·32	4·46	4·60	4·74	4·88	5·02	5·16	5·30	5·44	5·58	5·72
		I		79·5	81·3	83·1	84·8	86·5	88·2	89·9	91·6	93·3	95·0	96·6	98·2
		$I/_Y$		12·35	12·65	13·0	13·3	13·6	13·9	14·25	14·55	14·85	15·2	15·5	15·8
8	·44	A			4·69	4·85	5·01	5·17	5·33	5·49	5·65	5·81	5·97	6·13	6·29
		I			112·2	114·7	117·2	119·7	122·1	124·5	126·9	129·3	131·6	133·9	136·2
		$I/_Y$			15·5	15·9	16·3	16·7	17·1	17·5	17·9	18·3	18·7	19·1	19·5
9	·44	A				5·14	5·32	5·50	5·68	5·86	6·04	6·22	6·40	6·58	6·76
		I				149·7	153·1	156·5	159·9	163·3	166·7	170·0	173·2	176·4	179·5
		$I/_Y$				18·6	19·15	19·65	20·15	20·65	21·15	21·65	22·15	22·65	23·15
10	·45	A					5·67	5·87	6·07	6·27	6·47	6·67	6·87	7·07	7·27
		I					197·0	201·5	206·0	210·4	214·8	219·1	223·3	227·5	231·7
		$I/_Y$					22·4	23·0	23·6	24·2	24·8	25·4	26·0	26·6	27·2

DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
			·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74
6	·38	A	5·15	5·27	5·39	5·51	5·63	5·75	5·87	5·99	6·11				
		I	67·1	68·2	69·3	70·4	71·4	72·4	73·4	74·4	75·4				
		$I/_Y$	12·35	12·6	12·85	13·05	13·3	13·5	13·75	13·95	14·15				
7	·42	A	5·86	6·00	6·14	6·28	6·42	6·56	6·70	6·84	6·98	7·12			
		I	99·8	101·4	103·0	104·6	106·1	107·6	109·1	110·6	112·1	113·6			
		$I/_Y$	16·1	16·4	16·7	17·05	17·35	17·6	17·9	18·2	18·55	18·85			
8	·44	A	6·45	6·61	6·77	6·93	7·09	7·25	7·41	7·57	7·73	7·89	8·05		
		I	138·5	140·8	143·0	145·2	147·4	149·6	151·8	154·0	156·1	158·2	160·3		
		$I/_Y$	19·9	20·3	20·65	21·05	21·4	21·8	22·2	22·6	22·95	23·35	23·7		
9	·44	A	6·94	7·12	7·30	7·48	7·66	7·84	8·02	8·20	8·38	8·56	8·74	8·92	
		I	182·6	185·7	188·7	191·7	194·7	197·7	200·6	203·5	206·4	209·3	212·1	214·9	
		$I/_Y$	23·6	24·1	24·55	25·0	25·5	26·0	26·45	26·9	27·35	27·85	28·3	28·75	
10	·45	A	7·47	7·67	7·87	8·07	8·27	8·47	8·67	8·87	9·07	9·27	9·47	9·67	9·87
		I	235·9	240·0	244·0	248·0	251·9	255·8	259·7	263·5	267·3	271·1	274·9	278·7	282·4
		$I/_Y$	27·8	28·35	28·95	29·5	30·1	30·65	31·25	31·8	32·4	33·0	33·5	34·05	34·6

GEOMETRICAL PROPERTIES OF SECTIONS

TABLE 56 (SEE CONTINUATION)

CHANNELS HAVING $3\frac{1}{2}$-in. FLANGE



A = Sectional area of channel in square inches.
I = Moment of inertia about neutral axis XX in inch units.
$I/_Y$ = Modulus of resistance of section in inch units.
} In conjunction with plating.

DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
			·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50
6	·48	A	4·73	4·85	4·97	5·09	5·21	5·33	5·45	5·57	5·69	5·81	5·93	6·05	6·17
		I	67·4	68·4	69·4	70·5	71·5	72·6	73·6	74·7	75·7	76·8	77·8	78·9	79·9
		$I/_Y$	12·3	12·5	12·7	12·95	13·15	13·4	13·65	13·9	14·1	14·35	14·55	14·8	15·05
7	·50	A		5·24	5·38	5·52	5·66	5·80	5·94	6·08	6·22	6·36	6·50	6·64	6·78
		I		97·8	99·4	101·0	102·6	104·2	105·7	107·3	108·8	110·4	111·9	113·4	115·0
		$I/_Y$		15·55	15·85	16·15	16·45	16·8	17·1	17·4	17·7	18·0	18·3	18·6	18·9
8	·52	A				5·94	6·10	6·26	6·42	6·58	6·74	6·90	7·06	7·22	7·38
		I				138·3	140·6	142·9	145·2	147·5	149·7	151·9	154·1	156·3	158·4
		$I/_Y$				19·65	20·05	20·40	20·8	21·15	21·55	21·95	22·35	22·75	23·15
9	·54	A				6·37	6·55	6·73	6·91	7·09	7·27	7·45	7·63	7·81	7·99
		I				183·0	186·0	189·5	192·5	196·0	199·0	202·0	205·0	208·0	210·5
		$I/_Y$				22·35	23·85	24·35	24·85	25·35	25·85	26·35	26·85	27·3	27·8
10	·56	A					6·99	7·19	7·39	7·59	7·79	7·99	8·19	8·39	8·59
		I					240·0	244·0	248·0	252·0	256·0	260·0	264·0	268·0	272·0
		$I/_Y$					28·0	28·6	29·2	29·8	30·35	30·9	31·5	32·1	32·7
12	·50	A					7·31	7·55	7·79	8·03	8·27	8·51	8·75	8·99	9·23
		I					348·0	354·5	361·0	368·0	375·0	381·5	388·0	394·5	401·0
		$I/_Y$					34·1	35·0	35·8	36·6	37·5	38·3	39·1	39·9	40·8
12	·60	A						8·12	8·36	8·60	8·84	9·08	9·32	9·56	9·80
		I						381·0	387·5	394·0	400·5	407·0	413·5	420·0	426·0
		$I/_Y$						38·0	38·8	39·6	40·45	41·3	42·15	43·0	43·75

DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
			·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76
6	·48	A	6·29	6·41	6·53	6·65	6·77	6·89	7·01						
		I	81·0	82·1	83·2	84·3	85·4	86·6	87·7						
		$I/_Y$	15·3	15·55	15·8	16·0	16·25	16·5	16·75						
7	·50	A	6·92	7·06	7·20	7·34	7·48	7·62	7·76	7·90					
		I	116·5	118·0	119·5	121·0	122·4	123·8	125·2	126·6					
		$I/_Y$	19·2	19·5	19·8	20·1	20·4	20·7	21·0	21·3					
8	·52	A	7·54	7·70	7·86	8·02	8·18	8·34	8·50	8·66	8·82				
		I	160·5	162·6	164·7	166·8	168·9	170·9	172·9	174·9	176·9				
		$I/_Y$	23·45	23·85	24·25	24·7	25·05	25·4	25·8	26·2	26·5				
9	·54	A	8·17	8·35	8·53	8·71	8·89	9·07	9·25	9·43	9·61	9·79			
		I	213·5	216·5	219·5	222·5	225·0	228·0	230·5	233·5	236·0	239·0			
		$I/_Y$	28·25	28·7	29·2	29·7	30·15	30·6	31·05	31·5	32·0	32·5			
10	·56	A	8·79	8·99	9·19	9·39	9·59	9·79	9·99	10·19	10·39	10·59	10·79		
		I	276·0	280·0	284·0	288·0	291·5	295·0	298·5	302·0	305·5	309·0	312·0		
		$I/_Y$	33·3	33·9	34·5	35·1	35·65	36·2	36·75	37·3	37·85	38·4	38·9		
12	·50	A	9·47	9·71	9·95	10·19	10·43	10·67	10·91	11·15	11·39	11·63	11·87	12·11	12·35
		I	407·5	414·0	420·0	426·0	432·0	438·0	444·0	450·0	456·0	462·0	468·0	474·0	479·0
		$I/_Y$	41·6	42·4	43·2	44·0	44·8	45·6	46·35	47·1	47·9	48·7	49·5	50·25	51·0
12	·60	A	10·04	10·28	10·52	10·76	11·00	11·24	11·48	11·72	11·96	12·20	12·44	12·68	12·92
		I	432·0	438·0	444·0	450·0	456·0	462·0	468·0	474·0	480·0	486·0	491·5	497·0	502·5
		$I/_Y$	44·5	45·3	46·1	46·9	47·7	48·45	49·2	50·0	50·85	51·7	52·45	53·2	54·0

TABLE 56

(SEE CONTINUATION)

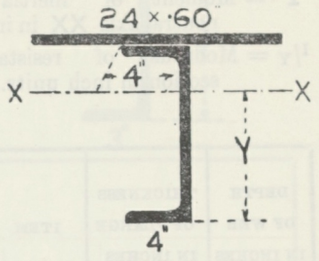
GEOMETRICAL PROPERTIES OF SECTIONS

A = Sectional area of channel in square inches.

I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating

I/Y = Modulus of resistance of section in inch units. } In conjunction with plating

CHANNELS HAVING 4-in. FLANGE



DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES									
			·38	·40	·42	·44	·46	·48	·50	·52	·54	·56
12	·60	A	8·97	9·21	9·45	9·69	9·93	10·17	10·41	10·65	10·89	11·13
		I	417·0	423·0	429·5	435·5	442·0	448·0	454·5	460·5	466·5	472·0
		I/Y	42·20	43·00	43·80	44·60	45·40	46·20	47·00	47·80	48·60	49·40
15	·62	A		10·55	10·85	11·15	11·45	11·75	12·05	12·35	12·65	12·95
		I		716·5	728·0	739·5	751·0	762·5	773·5	784·5	795·0	806·0
		I/Y		59·70	60·95	62·15	63·35	64·60	65·85	67·05	68·25	69·45
17	·68	A				12·36	12·70	13·04	13·38	13·72	14·06	14·40
		I				1020·5	1035·5	1050·5	1065·5	1080·5	1095·5	1110·0
		I/Y				77·05	78·55	80·05	81·60	83·10	84·60	86·10

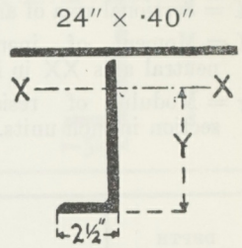
DEPTH OF WEB IN INCHES	THICKNESS OF FLANGE IN INCHES	ITEM	THICKNESS OF WEB IN INCHES									
			·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78
12	·60	A	11·37	11·61	11·85	12·09	12·33	12·57	12·81	13·05	13·29	13·53	13·77
		I	478·0	484·0	489·5	495·5	501·0	506·5	512·5	518·0	523·0	528·5	534·0
		I/Y	50·20	51·00	51·80	52·60	53·35	54·15	54·90	55·65	56·45	57·20	57·95
15	·62	A	13·25	13·55	13·85	14·15	14·45	14·75	15·05	15·35	15·65	15·95	16·25
		I	816·5	827·5	837·5	848·0	858·0	868·0	878·5	888·0	898·0	908·0	917·5
		I/Y	70·65	71·80	73·00	74·20	75·35	76·50	77·70	78·85	80·00	81·10	82·20
17	·68	A	14·74	15·08	15·42	15·76	16·10	16·44	16·78	17·12	17·46	17·80	18·14
		I	1125·0	1139·5	1154·0	1168·0	1182·5	1196·5	1210·5	1224·0	1237·5	1251·0	1264·5
		I/Y	87·55	89·00	90·50	92·00	93·45	94·90	96·35	97·80	99·25	100·65	102·05

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 2½-in. FLANGE

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units.
$I/_Y$ = Modulus of resistance of section in inch units.
} In conjunction with plating.



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·20	·22	·24	·26	·28	·30	·32	·34	·36
2½	A	·96	1·05	1·14	1·23	1·32	1·41	1·50	1·58	1·67
	I	4·2	4·5	4·9	5·2	5·5	5·8	6·0	6·3	6·5
	$I/_Y$	1·7	1·8	2·0	2·1	2·2	2·3	2·5	2·6	2·7
3	A	1·06	1·16	1·26	1·36	1·46	1·56	1·66	1·75	1·85
	I	6·2	6·7	7·2	7·6	8·1	8·5	8·9	9·3	9·6
	$I/_Y$	2·1	2·3	2·4	2·6	2·8	2·9	3·1	3·2	3·4
3½	A		1·27	1·38	1·49	1·60	1·71	1·82	1·92	2·03
	I		9·4	10·1	10·7	11·4	12·0	12·6	13·1	13·7
	$I/_Y$		2·8	3·0	3·2	3·4	3·6	3·8	4·0	4·2

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·38	·40	·42	·44	·46	·48	·50	·52	·54
2½	A	1·76	1·84	1·92	2·01	2·09	2·17	2·25		
	I	6·8	7·0	7·2	7·4	7·6	7·8	7·9		
	$I/_Y$	2·8	2·9	3·0	3·1	3·2	3·3	3·4		
3	A	1·95	2·04	2·13	2·23	2·32	2·41	2·50	2·59	2·68
	I	10·0	10·3	10·7	11·0	11·3	11·6	11·9	12·1	12·4
	$I/_Y$	3·5	3·7	3·8	4·0	4·1	4·2	4·3	4·4	4·6
3½	A	2·14	2·24	2·34	2·45	2·55	2·65	2·75	2·85	2·95
	I	14·2	14·7	15·1	15·5	16·0	16·4	16·8	17·1	17·5
	$I/_Y$	4·4	4·6	4·7	4·9	5·0	5·2	5·3	5·5	5·6

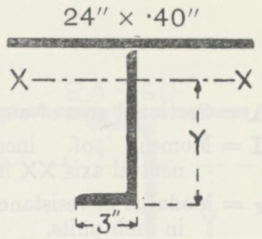
TABLE 56

(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 3-in. FLANGE



A = Sectional area of angle in square inches.

I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.

$I/_Y$ = Modulus of resistance of section in inch units. } In conjunction with plating.

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·26	·28	·30	·32	·34	·36	·38	·40	·42
3	A	1·49	1·60	1·71	1·82	1·92	2·03	2·14	2·24	2·34
	I	8·6	9·1	9·6	10·0	10·5	10·9	11·3	11·7	12·1
	$I/_Y$	3·0	3·2	3·4	3·6	3·7	3·9	4·1	4·2	4·4
3½	A	1·62	1·74	1·86	1·98	2·09	2·21	2·33	2·44	2·55
	I	12·0	12·7	13·3	14·0	14·6	15·2	15·8	16·4	16·9
	$I/_Y$	3·6	3·9	4·1	4·3	4·5	4·7	5·0	5·2	5·4
4	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76
	I	16·3	17·1	17·9	18·8	19·6	20·4	21·2	22·0	22·7
	$I/_Y$	4·4	4·6	4·9	5·1	5·4	5·6	5·9	6·1	6·4
5	A	2·01	2·16	2·31	2·46	2·60	2·75	2·90	3·04	3·18
	I	26·4	27·9	29·4	30·9	32·3	33·6	34·9	36·2	37·4
	$I/_Y$	5·7	6·1	6·5	6·9	7·3	7·6	8·0	8·3	8·7
6	A	2·27	2·44	2·61	2·78	2·94	3·11	3·28	3·44	3·60
	I	40·0	42·4	44·6	46·8	48·9	50·9	52·8	54·7	56·6
	$I/_Y$	7·4	7·9	8·4	8·9	9·3	9·8	10·3	10·7	11·1

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES								
		·44	·46	·48	·50	·52	·54	·56	·58	·60
3	A	2·45	2·55	2·65	2·75	2·85	2·95	3·05	3·14	
	I	12·4	12·8	13·1	13·4	13·7	14·0	14·3	14·6	
	$I/_Y$	4·6	4·7	4·9	5·0	5·2	5·3	5·4	5·5	
3½	A	2·67	2·78	2·89	3·00	3·11	3·22	3·33	3·43	3·54
	I	17·4	17·9	18·4	18·9	19·3	19·7	20·1	20·5	20·8
	$I/_Y$	5·6	5·8	6·0	6·1	6·3	6·5	6·6	6·8	6·9
4	A	2·89	3·01	3·13	3·25	3·37	3·49	3·61	3·72	3·84
	I	23·4	24·1	24·8	25·4	26·0	26·5	27·1	27·6	28·1
	$I/_Y$	6·6	6·9	7·1	7·3	7·6	7·8	8·0	8·2	8·4
5	A	3·33	3·47	3·61	3·75	3·89	4·03	4·17	4·30	4·44
	I	38·6	39·8	40·9	41·9	42·9	43·9	44·8	45·8	46·7
	$I/_Y$	9·0	9·3	9·6	9·9	10·2	10·5	10·8	11·1	11·3
6	A	3·77	3·93	4·09	4·25	4·41	4·57	4·73	4·88	5·04
	I	58·4	60·2	62·0	63·6	65·1	66·6	68·2	69·7	71·0
	$I/_Y$	11·6	12·0	12·4	12·8	13·2	13·6	14·0	14·4	14·7

TABLE 56

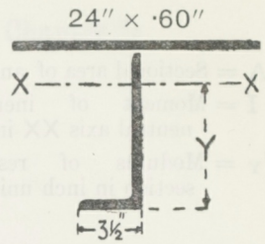
(SEE CONTINUATION)

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 3½-in. FLANGE

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·26	·28	·30	·32	·34	·36	·38	·40	·42	·44	·46	·48
3½	A	1·75	1·88	2·01	2·14	2·26	2·39	2·52	2·64	2·76	2·89	3·01	3·13
	I	15·2	16·1	16·9	17·8	18·6	19·3	20·1	20·9	21·6	22·3	22·9	23·6
	$I/_Y$	4·4	4·6	4·9	5·2	5·4	5·7	5·9	6·2	6·4	6·7	6·9	7·1
4	A	1·88	2·02	2·16	2·30	2·43	2·57	2·71	2·84	2·97	3·11	3·24	3·37
	I	20·0	21·1	22·2	23·3	24·3	25·4	26·4	27·4	28·4	29·4	30·4	31·3
	$I/_Y$	5·1	5·4	5·7	6·0	6·3	6·7	7·0	7·3	7·5	7·8	8·1	8·4
5	A	2·14	2·30	2·46	2·62	2·77	2·93	3·09	3·24	3·39	3·55	3·70	3·85
	I	32·3	34·2	36·0	37·9	39·7	41·4	43·1	44·7	46·3	47·8	49·2	50·7
	$I/_Y$	6·7	7·2	7·6	8·0	8·5	8·9	9·3	9·7	10·1	10·5	10·8	11·2
6	A			2·76	2·94	3·11	3·29	3·47	3·64	3·81	3·99	4·16	4·33
	I			54·3	57·0	59·6	62·2	64·6	67·0	69·3	71·6	73·9	76·1
	$I/_Y$			9·7	10·2	10·7	11·2	11·8	12·3	12·8	13·3	13·8	14·3
7	A					3·45	3·65	3·85	4·04	4·23	4·43	4·62	4·81
	I					84·3	88·0	91·5	95·0	98·5	101·7	105·0	108·1
	$I/_Y$					13·3	13·9	14·6	15·3	15·9	16·5	17·2	17·8

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES											
		·50	·52	·54	·56	·58	·60	·62	·64	·66	·68	·70	·72	·74
3½	A	3·25	3·37	3·49	3·61	3·72	3·84	3·96	4·07					
	I	24·2	24·8	25·3	25·9	26·4	27·0	27·5	28·0					
	$I/_Y$	7·3	7·6	7·8	8·0	8·2	8·4	8·6	8·8					
4	A	3·50	3·63	3·76	3·89	4·01	4·14	4·27	4·39	4·51				
	I	32·2	33·0	33·7	34·5	35·2	36·0	36·7	37·3	37·8				
	$I/_Y$	8·7	8·9	9·2	9·5	9·7	9·9	10·1	10·4	10·6				
5	A	4·00	4·15	4·30	4·45	4·59	4·74	4·89	5·03	5·17	5·32	5·46		
	I	52·2	53·6	54·9	56·3	57·5	58·8	60·0	61·2	62·4	63·5	64·5		
	$I/_Y$	11·6	12·0	12·3	12·7	13·0	13·3	13·7	14·0	14·4	14·7	15·0		
6	A	4·50	4·67	4·84	5·01	5·17	5·34	5·51	5·67	5·83	6·00	6·16	6·32	6·48
	I	78·3	80·5	82·5	84·5	86·5	88·4	90·3	92·0	93·7	95·4	97·1	98·6	100·2
	$I/_Y$	14·8	15·3	15·7	16·2	16·7	17·1	17·6	18·0	18·4	18·8	19·2	19·6	20·0
7	A	5·00	5·19	5·38	5·57	5·75	5·94	6·13	6·31	6·49	6·68	6·86	7·04	7·22
	I	111·2	114·2	117·0	119·8	122·5	125·2	127·8	130·4	132·8	135·2	137·7	140·0	142·2
	$I/_Y$	18·3	18·9	19·5	20·1	20·6	21·2	21·7	22·3	22·8	23·3	23·8	24·3	24·8

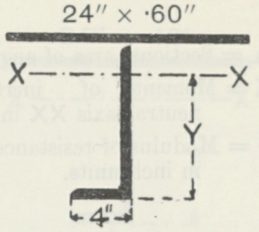
TABLE 56
(CONCLUDED)

GEOMETRICAL PROPERTIES OF SECTIONS

INVERTED ANGLES

HAVING 4-in. FLANGE

A = Sectional area of angle in square inches.
I = Moment of inertia about neutral axis XX in inch units. } In conjunction with plating.
$I/_Y$ = Modulus of resistance of section in inch units. }



DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
		·30	·32	·34	·36	·38	·40	·42	·44	·46	·48	·50	·52	·54
4	A	2·31	2·46	2·60	2·75	2·90	3·04	3·18	3·33	3·47	3·61	3·75	3·89	4·03
	I	24·4	25·7	26·9	28·1	29·3	30·4	31·4	32·4	33·3	34·3	35·2	36·1	37·0
	$I/_Y$	6·4	6·7	7·1	7·4	7·8	8·1	8·4	8·7	9·0	9·3	9·6	9·9	10·2
5	A	2·61	2·78	2·94	3·11	3·28	3·44	3·60	3·77	3·93	4·09	4·25	4·41	4·57
	I	39·0	41·0	43·0	44·9	46·7	48·5	50·2	51·9	53·5	55·1	56·7	58·2	59·6
	$I/_Y$	8·3	8·8	9·2	9·7	10·1	10·6	11·0	11·5	11·9	12·3	12·7	13·2	13·6
6	A			3·38	3·47	3·66	3·84	4·02	4·21	4·39	4·57	4·75	4·93	5·11
	I			63·2	66·0	68·8	71·6	74·3	76·8	79·3	81·7	84·0	86·4	88·6
	$I/_Y$			11·5	12·1	12·7	13·3	13·8	14·4	15·0	15·5	16·1	16·6	17·1
8	A						4·64	4·86	5·09	5·31	5·53	5·75	5·97	6·19
	I						138·0	142·7	147·3	151·9	156·4	160·8	165·0	169·3
	$I/_Y$						19·8	20·6	21·4	22·2	23·0	23·8	24·6	25·4
9	A							5·28	5·53	5·77	6·01	6·25	6·49	6·73
	I							185·0	191·3	197·6	203·6	209·6	215·6	221·4
	$I/_Y$							24·1	25·1	26·1	27·1	28·1	29·0	30·0
10	A								5·97	6·23	6·49	6·75	7·01	7·27
	I								243·7	251·5	259·2	266·8	274·1	281·3
	$I/_Y$								29·1	30·2	31·3	32·4	33·6	34·7

DEPTH OF WEB IN INCHES	ITEM	THICKNESS OF WEB IN INCHES												
		·56	·58	·60	·62	·64	·66	·68	·70	·72	·74	·76	·78	·80
4	A	4·17	4·30	4·44	4·58	4·71	4·84							
	I	37·9	38·7	39·6	40·4	41·3	42·1							
	$I/_Y$	10·5	10·8	11·1	11·4	11·7	12·0							
5	A	4·73	4·88	5·04	5·20	5·35	5·50	5·66	5·81					
	I	61·1	62·5	63·9	65·2	66·5	67·7	68·9	70·0					
	$I/_Y$	14·0	14·4	14·7	15·1	15·5	15·8	16·2	16·5					
6	A	5·29	5·46	5·64	5·82	5·99	6·16	6·34	6·51	6·68	6·85			
	I	90·7	92·8	94·8	96·8	98·7	100·6	102·4	104·1	105·8	107·5			
	$I/_Y$	17·6	18·1	18·6	19·1	19·6	20·0	20·5	20·9	21·3	21·8			
8	A	6·41	6·62	6·84	7·06	7·27	7·48	7·70	7·91	8·12	8·33	8·54	8·75	8·96
	I	173·5	177·5	181·5	185·3	189·0	192·6	196·2	199·6	202·9	206·0	209·0	212·0	214·8
	$I/_Y$	26·2	26·9	27·7	28·5	29·2	29·9	30·6	31·3	32·0	32·6	33·2	33·8	34·4
9	A	6·97	7·20	7·44	7·68	7·91	8·14	8·38	8·61	8·84	9·07	9·30	9·53	9·76
	I	226·9	232·2	237·5	242·5	247·5	252·2	256·8	261·3	265·7	270·0	274·3	278·5	282·7
	$I/_Y$	30·9	31·8	32·7	33·6	34·4	35·3	36·2	37·0	37·8	38·6	39·4	40·2	41·0
10	A	7·53	7·78	8·04	8·30	8·55	8·80	9·06	9·31	9·56	9·81	10·06	10·31	10·56
	I	288·4	295·3	302·0	308·7	315·3	321·6	327·8	333·8	339·6	345·1	350·3	355·3	360·0
	$I/_Y$	35·8	36·9	38·0	39·0	40·1	41·1	42·1	43·1	44·0	45·0	45·9	46·7	47·5

OIL TANKERS

Section 40

GENERAL

Application

4001 The following Rules apply to the Class 100A1 Oil Tanker. (*See* B 103.) The scantlings and arrangements of tankers intended for cargoes other than petroleum will be specially considered in relation to the nature and density of the cargo.

Sections D 1 to D 33 apply to tankers except as otherwise required by the following Rules.

Method of Construction

4002 The following Rules and Tables give requirements for welded construction with certain modifications when riveting is adopted.

Structural Design

4003 The Rules apply to single deck tankers of 300 feet in length and over with machinery aft and having two or more longitudinal bulkheads.

The bottom and deck are to be framed longitudinally in the cargo tank spaces; the Rules assume longitudinal framing at the sides and longitudinal bulkheads where the length of the ship exceeds 650 feet, but alternative designs will be specially considered.

Where the breadth B exceeds 105 feet but does not exceed 110 feet the thickness of the side longitudinal bulkheads is to be increased as given in D 5006.

A centre line bulkhead, which may be perforated, is generally to be fitted where the breadth B exceeds 110 feet. Where, however, the breadth of the centre tank does not exceed 55 feet special consideration will be given to the omission of the centre line bulkhead provided the thickness of the side longitudinal bulkheads is increased as given in D 5006 and bottom and deck side girders of increased scantlings are fitted. (*See also* 4008.)

If the proportion of length to depth exceeds fourteen or the ratio of breadth to depth exceeds 1·9 at 500 feet and below, or 2·1 at 700 feet and above, with intermediate values in proportion, increased scantlings may be required.

Loading

4004 The Rules are framed on the understanding that the loading will be homogeneous over the full range of cargo tanks (unless certain tanks are intended to be dry or arranged for water ballast only) and with the ship in a reasonable service trim.

Any dry tanks, or tanks intended for water ballast only and thus empty in the loaded condition, are to be indicated on the plans submitted for approval and the arrangements are to be such that these tanks cannot be used for any other purpose.

4005 Schemes of loading covering the normal cargo and ballast conditions are to be submitted for approval as early as possible; particulars of the light ship weight and weight of machinery are to be supplied.

In order to guard against high stresses being imposed through an unsatisfactory cargo or ballast loading it is recommended that tankers be supplied with an approved instrument for determining suitable loading.

Quality of Material

4006 Where the thickness of plating exceeds ·80 inch and the seams (other than those covered by 4007) and butts are welded, steel of grade D (*see* P 2, Table II) will generally be required for the following parts of the structure :—

(*a*) Sheerstrake, strength deck stringer and plating, top strake of the longitudinal bulkhead, deck longitudinals of the slab type where cut from plates and through brackets for deck longitudinals.

This grade D plating is to extend from ·15L aft of amidships to ·15L forward of amidships where the length is 500 feet and below, and from ·2L aft of amidships to ·2L forward of amidships where the length is 700 feet and above, with intermediate values obtained by interpolation, always provided that the forward limit extends at least 10 feet forward of the bridge front.

In addition, the sheerstrake and strength deck stringer and plating are to be of grade D in way of the poop front, extending forward to cover any pump room openings. Any stringer, deck or sheerstrake plating between the above after limit of the midship portion and ·25L aft of amidships which is above 1·00 inch in thickness should also be of grade D.

(*b*) Bottom shell plating to upper turn of bilge, bottom strake of the longitudinal bulkhead, bottom longitudinals of the slab type cut from plates and through brackets of bottom longitudinals.

This grade D plating is to extend from ·15L aft of amidships to ·15L forward of amidships where the length is 500 feet and below, and from ·25L aft of amidships to ·2L forward of amidships where the length is 700 feet and above with intermediate values obtained by interpolation.

In addition, the bottom plating between the above after limit and ·25L aft of amidships is to be of grade D where the thickness is above 1·00 inch. Where the bottom plating is required to be of steel of the above grade, the keel plate is also to be of the same grade.

4007 Strakes of steel of specially high notch toughness (grade E) or riveted seams are to be arranged as follows:—

LENGTH L		Grade E Strakes	Riveting
Over	Not exceeding		
Feet	Feet		
400	500	Bilge strake	Seams of bilge strake
500	550	Sheerstrake Bilge strake	Stringer angle Seams of bilge strake
550	600	Sheerstrake Bilge strake Bottom strake in way of longitudinal bulkhead	Stringer angle Seams of bilge strake Bottom seam in way of longitudinal bulkhead
600	700	Sheerstrake* Deck stringer plate* Bilge strake Deck strake in way of longitudinal bulkhead Bottom strake in way of longitudinal bulkhead	Stringer angle Lower edge of sheerstrake Seams of bilge strake Deck seam in way of longitudinal bulkhead Bottom seam in way of longitudinal bulkhead
700		As for tankers over 600 feet but the keel is also to be grade E when the breadth exceeds 110 feet or when the breadth of centre tank is excessive The deck centre line strake may require to be of grade E steel if the breadth of centre tank is excessive	As for tankers over 600 feet but the inboard seam of the stringer plate is to be riveted When the breadth exceeds 110 feet, or the breadth of the centre tank is excessive, the keel seams are to be riveted The seams of the deck centre line strake may require to be riveted if the breadth of the centre tank is excessive

* Or rounded sheerstrake only if this arrangement is adopted

The fore and aft extent of the grade E strakes or riveting is to be as follows:—

(a) Sheerstrake and deck plating from within the poop to ·2L forward of amidships.

(b) Bottom and bilge plating from ·25L aft of amidships to ·2L forward of amidships.

The breadth of each strake is not to be less than 60 inches except that the bilge strake shall not be less than 72 inches.

Length and Breadth of Cargo Tanks

4008 Where the length of a tank exceeds 50 feet a transverse wash bulkhead is to be fitted.

Where the breadth of centre tank exceeds 55 feet a centre line bulkhead is to be fitted. (*See also* 4003 and D 5029.)

Cofferdams

4009 Cofferdams are to be provided at the forward and after ends of the oil cargo spaces; cofferdams are to be at least 2 feet 6 inches in length and are to cover the whole area of the end bulkheads of the cargo spaces.

Pump rooms or water ballast tanks will be accepted in lieu of a cofferdam. An oil fuel bunker will also be accepted provided the bulkhead between it and the cargo tank is completely welded.

An intact cofferdam is also to be arranged between the crown of a cargo oil tank and accommodation spaces or spaces containing electrical equipment. (*See also* M 1605.) Where the bridge 'tween deck space acts as a cofferdam, any access to this 'tween deck from the deck above is to be from the open deck.

Superstructures

4010 A forecastle of not less than ·07L in length is to be fitted.

The machinery casings on the strength deck are to be protected by a poop or deckhouse of equivalent strength.

Freeing Arrangements and Gangway

4011 Ships with bulwarks are to have open rails fitted for at least half the length of the exposed part of each well.

A strong permanent fore and aft gangway is to be fitted at the level of the superstructure decks. Where there is no accommodation forward, the gangway between the bridge and forecastle may be omitted and where there is no midship erection and all accommodation, etc., is aft, the gangway may be omitted entirely. Arrangements are, however, to be made to give safe access to the fore end of the ship.

Submission of Plans

4012 In addition to the plans required by D 108, plans showing the construction of the transverse and longitudinal oiltight bulkheads, end connections for all longitudinals and other framing members, the structure at the ends of the ship, deckhouses protecting machinery casings and arrangements at the junction of transverse and longitudinal framing are also to be submitted.

A plan showing the arrangement and sequence of erection of the fabrication units is to be submitted.

4013 The information required by D 4102 is to be forwarded when the midship section is submitted.

Equipment

4014 The equipment of anchors, chain cables, wires and ropes is to be as required by Table 53 and associated notes. The "Equipment Number" is to be determined in accordance with D 3303, except that for ships without sheer in way of ·5L amidships the depth for calculating the Hull Number may be taken as 97 per cent of the depth moulded amidships.

Anodes in Tanks

4015 When anodes are fitted in tanks they are to be of approved design and securely attached to the structure, both initially and during service. A plan showing the details of design and attachment and the location of the anodes is to be submitted.

Section 41

LONGITUDINAL STRENGTH

General

4101 The required areas of bottom shell and strength deck plating amidships are to be obtained from Table 62. The areas are related to a numeral N which is to be determined in accordance with 4103 below.

Definitions

4102

W = moulded displacement at draught d (*See* below) — Tons

L = length of ship (*See* D 201) — Feet

d = summer draught measured from top of keel — ,,

B = moulded breadth — Feet

D = moulded depth — ,,

m = weight of main and auxiliary machinery and boilers in service condition, uptakes, generators, pumps, compressors, piping, flooring, gratings, ladders, stores, spare parts, loose tanks and fittings in the machinery compartment but excluding cargo pumps, propeller, shafting and funnel — Tons

C_b = moulded block coefficient at draught equal to ·06L

l = total cargo tank length — Feet

l_f = cargo tank length forward of midships — ,,

l_a = cargo tank length aft of midships — ,,

l^1 = equivalent* length of empty tank, cofferdam, pump room, etc., within length l — ,,

x = distance of centre of gravity of empty tank from amidships — ,,

* Equivalent length is defined as $\frac{\text{"empty tank volume"}}{B \times D}$

An empty tank is a dry or water ballast tank as defined in D 4004.

Effective Numeral

4103 The value of Numeral N to be used in Table 62 depends on the relative values of N_1 and N_2 (*See* 4104 and 4105) and

If N_1 is greater than N_2 then $N = N_1$

If N_2 is greater than N_1 then $N = \frac{N_1 + 2N_2}{3}$

If N_2 is negative, special consideration will be given to the scantlings required.

Determination of N_1

4104 The numeral N_1 is given by

$$N_1 = K\,B\,C_b$$

The value of K is found from Table 60.

Where the block coefficient (at a draught of ·06L) is less than ·75 the scantlings will be specially considered.

TABLE 60

VALUES OF K

LENGTH L	K	Difference in K per 1 foot difference in L
Feet		
300	0·286	0·0009
310	0·295	0·0011
320	0·306	0·0013
330	0·319	0·0014
340	0·333	0·0016
350	0·349	0·0017
360	0·366	0·0019
370	0·385	0·0020
380	0·405	0·0021
390	0·426	0·0022
400	0·448	0·0023
410	0·471	0·0024
420	0·495	0·0025
430	0·520	0·0026
440	0·546	0·0027
450	0·573	0·0028
460	0·601	0·0029
470	0·630	0·0030
480	0·660	0·0031
490	0·691	0·0032
500	0·723	0·0033
510	0·756	0·0034
520	0·790	0·0035
530	0·825	0·0036
540	0·861	0·0036
550	0·898	0·0037
560	0·936	0·0038
570	0·974	0·0038
580	1·013	0·0039
590	1·053	0·0040
600	1·094	0·0041
610	1·136	0·0042
620	1·179	0·0043
630	1·223	0·0044
640	1·269	0·0046
650	1·316	0·0047
660	1·364	0·0048
670	1·414	0·0050
680	1·465	0·0051
690	1·517	0·0052
700	1·571	0·0054
710	1·626	0·0055
720	1·682	0·0056
730	1·740	0·0058
740	1·799	0·0059
750	1·859	0·0060
760	1·921	0·0062
770	1·984	0·0063
780	2·048	0·0064
790	2·114	0·0066
800	2·181	0·0067
810	2·249	0·0068
820	2·319	0·0070
830	2·390	0·0071
840	2·462	0·0072
850	2·536	0·0074
860	2·611	0·0075
870	2·687	0·0076
880	2·765	0·0078
890	2·844	0·0079
900	2·924	0·0080
910	3·006	0·0082
920	3·089	0·0083
930	3·173	0·0084
940	3·259	0·0086
950	3·346	0·0087
960	3·434	0·0088
970	3·524	0·0090
980	3·615	0·0091
990	3·707	0·0092
1000	3·801	0·0094

Determination of N_2

4105 N_2 is to be calculated as follows:—

$$N_2 = \frac{95\ e\ WL}{10^6\ (2300 + L)}$$

The value of e is given by the algebraic sum of the following basic value and corrections:—

Basic value of $e = 125 - \frac{300{,}000}{W}$

1st correction $= -\frac{m}{W}\ (1000+24P)$ (*See also* note 4 below)

2nd correction $= 18\ (P-4)$

3rd correction $= 700\ (C_b - \cdot 80)$

4th correction $= 1530\left(\frac{d}{L} - \cdot 053\right)$

5th correction $= -3830\frac{l^1}{l}\left(\cdot 1784 - \cdot 0046P - \frac{x}{L}\right)\left(1+\frac{l^1}{l}\right)$

The value of P is found from Table 61.

NOTES.— 1 $\frac{d}{L}$ and $\frac{x}{L}$ should be worked to four significant figures.

2 Corrections for each empty compartment must be made separately and where an empty compartment covers amidships the portions forward and aft of amidships are to be treated as two separate compartments.

3 The formulæ are applicable to ships having no sheer over ·5L amidships. Ships with sheer extending an unusual distance into ·5L amidships, or with an abnormal sheer at ends, will require special consideration.

4 Where there is no amidship erection other than a pump room casing and all accommodation is in the poop, the ratio of the machinery weight, m/W, in the first correction is to be increased by ·006. This correction then becomes:—

$$-\left(\frac{m}{W} + \cdot 006\right)\ (1000 + 24P)$$

Determination of Bottom and Deck Areas

4106 The required bottom and deck areas corresponding to the effective Numeral N are to be obtained from Table 62 and Notes. The area derived from the Table and corrected as required by Note (1) is the bottom area. The deck area is to be 95 per cent of the corrected bottom area.

Section 42

DECKS

Strength Deck

4201 The thickness of deck plating derived in accordance with D 41 is to be maintained from ·25L aft of amidships to ·2L forward of amidships and is to be gradually tapered to the end thickness.

4202 The thickness at the poop front is to extend into the poop for a distance at least equal to one-third the breadth B.

Where the machinery opening extends forward beyond a point one-third of the breadth B abaft the poop front, and the width of the casing exceeds one-half the breadth of the ship at the poop front, the thickness of deck plating may require to be increased. The forward corners of the casing opening are to be well rounded.

4203 The thickness of the stringer plate at the ends of the bridge is to be increased by 20 per cent.

If the poop front extends within ·25L from amidships the stringer plate at the break is to be increased by 20 per cent. No increase is required if the poop front is ·3L from amidships or greater. The increase at intermediate lengths is to be obtained by interpolation and is to be applied to the tapered thickness of the stringer plate.

The increase in thickness need not exceed ·20 inch.

4204 The thickness of the deck stringer and plating for ·05L at ends is not to be less than $\left(\cdot 24 + \frac{L}{4000}\right)$ inches.

4205 If a stringer angle is fitted, in way of the cargo tanks and for at least one-third of the breadth B within the poop it is to have 6-inch flanges when the length L does not exceed 450 feet, 7-inch flanges for lengths exceeding 450 feet and not exceeding 550 feet and 8-inch flanges above 550 feet. The thickness is to be that of the sheerstrake or stringer whichever is less. Alternative riveted connections will be specially considered.

At the ends of the ship the scantlings of stringer angle are to be determined from Table 19.

If the stringer angle is cut at the scuppers, compensation is to be provided. (*See also* D 4308.)

4206 Where a rounded sheerstrake is incorporated the radius should, in general, not be less than 15 times the thickness. The radius should be made by careful cold rolling or bending. Where grade E plates are subjected to severe cold working or where local heating of the plates is adopted, the plates may require to be re-normalised.

4207 The corners of all deck openings are to be well rounded and smooth, and strength is to be maintained in way of pump room entrances or other openings but compensation will not, in general, be required forward of ·2L forward of amidships nor abaft the poop front bulkhead. It is recommended that compensation for deck openings should be in the form of an increased thickness of plating, but alternative methods will be specially considered.

Lower Decks

4208 The scantlings and arrangements of lower decks are to be as required by D 11, D 14 and D 15.

TABLE 61

VALUES OF P

$\frac{l}{L}$	$\frac{l_f}{l_a}$ = 1·1	Differences	$\frac{l_f}{l_a}$ = 1·2	Differences	$\frac{l_f}{l_a}$ = 1·3	Differences	$\frac{l_f}{l_a}$ = 1·4	Differences	$\frac{l_f}{l_a}$ = 1·5	Differences	$\frac{l_f}{l_a}$ = 1·6	Differences	$\frac{l_f}{l_a}$ = 1·7	$\frac{l}{L}$
·56	8·45	0·17	8·28	0·26	8·02	0·29	7·73	0·33	7·40	0·39	7·01	0·42	6·59	·56
		1·04 1·04		1·04 1·04		1·04 1·04		1·04 1·05		1·05 1·06		1·06 1·07		
·58	7·41	0·17	7·24	0·26	6·98	0·29	6·69	0·34	6·35	0·40	5·95	0·43	5·52	·58
		1·01 1·02		1·02 1·02		1·02 1·03		1·03 1·03		1·03 1·03		1·03 1·02		
·60	6·40	0·18	6·22	0·26	5·96	0·30	5·66	0·34	5·32	0·40	4·92	0·42	4·50	·60
		0·99 1·00		1·00 1·00		1·00 1·00		1·00 1·00		1·00 0·99		0·99 0·98		
·62	5·41	0·19	5·22	0·26	4·96	0·30	4·66	0·34	4·32	0·39	3·93	0·41	3·52	·62
		0·97 0·98		0·98 0·97		0·97 0·96		0·96 0·95		0·95 0·94		0·94 0·92		
·64	4·44	0·20	4·24	0·25	3·99	0·29	3·70	0·33	3·37	0·38	2·99	0·39	2·60	·64
		0·94 0·94		0·94 0·94		0·94 0·93		0·93 0·92		0·92 0·90		0·90 0·87		
·66	3·50	0·20	3·30	0·25	3·05	0·28	2·77	0·32	2·45	0·36	2·09	0·36	1·73	·66
		0·91 0·91		0·91 0·90		0·90 0·89		0·89 0·87		0·87 0·85		0·85 0·83		
·68	2·59	0·20	2·39	0·24	2·15	0·27	1·88	0·30	1·58	0·34	1·24	0·34	0·90	·68
		0·90 0·90		0·90 0·89		0·89 0·88		0·88 0·86		0·86 0·84		0·84 0·82		
·70	1·69	0·20	1·49	0·23	1·26	0·26	1·00	0·28	0·72	0·32	0·40	0·32	0·08	·70

NOTE.—TABLE 61

The values of P in the above Table correspond to a standard C_b of ·80 and where the C_b differs from ·80 the Table value is to be corrected as follows:—

$$P = \text{Table value} - 150\left(\frac{l}{L} - ·64\right)\left(C_b - ·80\right)$$

N	BASIC AREA	BASIC DEPTH D_1	DEPTH CORRECTION	MINIMUM BOTTOM THICKNESS	MINIMUM KEEL THICKNESS
1	2	3	4	5	6
	Sq. ins.	Feet	Sq. ins.	Ins.	Ins.
5	133	18·5	6	·40	·56
10	202	23·5	7	·46	·64
15	252	28·0	8	·51	·73
20	305	31·0	9	·55	·79
30	400	35·0	10	·62	·88
40	481	38·5	11	·68	·95
50	565	41·0	12	·73	1·01
70	713	45·0	14	·83	1·11
90	855	48·0	15	·91	1·21
120	1054	52·0	18	1·02	1·34
150	1256	55·0	20	1·11	1·43
190	1508	58·5	22	1·22	1·48
240	1793	62·5	25	1·32	1·50
290	2081	65·5	28	1·40	1·50
360	2451	69·5	32	1·47	1·50
430	2820	72·5	35	1·50	1·50

NOTES.—TABLE 62

1. Where the depth D is $\begin{matrix}\text{greater}\\\text{less}\end{matrix}$ than the basic depth D_1 the tabular bottom area is to be $\begin{matrix}\text{reduced}\\\text{increased}\end{matrix}$ at the rate per foot of difference given in column 4.

2. The bottom area is that for one side of the ship and includes the following items up to ·1D from the base line:—

One half the keel plate
Bottom and bilge plating
Bottom, bilge and side longitudinals
One half the centre girder
Side girders
Plating and longitudinal stiffeners of longitudinal bulkheads (including one half of a centre line bulkhead)

3. The deck area is that for one side of the ship in way of openings and includes the following items down to ·1D from the deck line at side:—

Deck stringer and plating
Sheerstrake
Stringer angle (if fitted)
Deck and side longitudinals
One half the centre line deck girder
Side girders
Plating and longitudinal stiffeners of longitudinal bulkheads (including one half of a centre line bulkhead).

4. Lightening holes in girders need not be deducted provided their depth does not exceed 20 per cent of the depth of the girder web.

Where longitudinals are scalloped the net area in way of scallop is to be used. Isolated drain holes need not be deducted, but compensation will be required for large drain holes at the bulkheads.

5. The thickness of bottom plating is not to be less than that given in column 5. This thickness need not be corrected for spacing unless this exceeds 35 inches at 400 feet and below or 40 inches at 900 feet and above, with intermediate values in proportion. Where this spacing is exceeded the thickness is to be increased at the rate of 2 per cent per inch increase.

6. The thickness of deck plating is not to be less than 80 per cent of that given in column 5 and is not, in general, to be corrected for longitudinal spacing.

4209 Abrupt discontinuities at the ends of lower decks and flats are to be avoided by suitable tapering of the stringer plates or by fitting large brackets.

Section 43

SHELL PLATING

Bottom Shell and Keel

4301 The thickness of bottom shell plating derived in accordance with D 41 is to be maintained from ·25L aft of amidships to ·2L forward of amidships and is to be gradually tapered to the end thickness. (*See* 4305.)

4302 The width of the keel is to be not less than ·07B in feet (where B is the moulded breadth) but need not exceed 72 inches. The thickness may be as given in D 4106 Table 62, but is not to be less than the bottom shell.

The width and thickness given above are to be maintained throughout.

Side Shell

4303 Within ·25L forward and ·25L aft of amidships the thickness of side shell is not to be less than $\frac{3 \cdot 4}{10^8}(L+4000)(d+30)(s+40)$ inches where L and d are as defined in D 4102 and s is the spacing of side longitudinals or side framing (as appropriate) in inches. In no case is the value of s used in this formula to be less than $\left(22+\frac{L}{75}\right)$ inches.

4304 The midship thickness of side shell is to be gradually tapered to the end thickness. (*See* 4305.)

End Thickness

4305 The thickness of shell plating for ·05L from ends is not to be less than $\left(\cdot 29+\frac{L}{2500}\right)$ inches.

Sheerstrake

4306 The width of sheerstrake from ·25L aft of amidships to ·2L forward of amidships is not to be less than ·15D in feet but need not exceed 84 inches and the thickness is not to be less than that of the deck plating or side shell, whichever is the greater.

At ends the thickness of sheerstrake may be the same as the side shell.

4307 The thickness of the sheerstrake is to be increased 20 per cent at the ends of the bridge, but this increase is not required if the bridge does not extend to the ship's side.

If the poop front at side extends within ·25L from amidships the sheerstrake at the break is to be increased by 20 per cent. No increase is required if the poop front at side is ·3L from amidships or greater. The increase at intermediate positions is to be obtained by interpolation and is to be applied to the tapered thickness of the sheerstrake.

4308 The upper edge of the sheerstrake is to be dressed smooth and kept free of isolated welded fittings or connections. In ships over 600 feet in length scupper openings are not to be cut above the deck.

Where a rounded sheerstrake is adopted, the welding of fairleads or other fittings to this plate is to be reduced to a minimum and details are to be submitted for approval.

Openings in Shell

4309 Sea inlets in pump rooms situated within ·5L amidships, are, if practicable, to be fitted clear of the bilge radius. All openings are to be arranged so as to minimise discontinuity of transverse frames, longitudinals or bilge keels. Compensation is to be provided for all openings within ·5L amidships and may be required for openings in the vicinity of the poop front. The compensation should, if possible, take the form of an insert plate rather than a doubler.

If the openings are not circular or oval the corners are to be rounded with as large a radius as practicable.

Bilge Keels

4310 Where bilge keels are fitted, it is desirable that they be attached to a continuous flat bar which may be welded to the shell. Scallops are to be arranged in way of welded butts in the flat bar. Alternative arrangements, or arrangements omitting the flat bar, will be specially considered.

Bilge keels are to be gradually tapered at their ends and are not to finish on an unstiffened panel.

Section 44

BOTTOM, SIDE AND DECK LONGITUDINALS

Scantlings

4401 The scantlings of longitudinals within the range of cargo tanks are not to be less than required by the following formulæ:—

Bottom longitudinals $\frac{I}{y} = \frac{s \times S^2 \times D}{1500}$ inches^3

Deck longitudinals $\frac{I}{y} = \frac{s \times S^2}{1200}\left\{3{\cdot}2 + \left(\frac{L}{300}\right)^3\right\}$ inches^3

Side ,, $\frac{I}{y} = \frac{s \times S^2}{2680}\left(h + \frac{D}{6}\right)$ inches^3

Where s = spacing of longitudinals in inches,

S = span in feet measured between transverses or from transverse to "span point" (minimum value 8 feet),

L = length of ship in feet,

h = distance of longitudinal below deck at side in feet,

D = moulded depth in feet.

The section modulus given by these formulæ is that of the longitudinal and associated plating. (*See* D 5301.)

The scantlings derived from the above, using the midship thickness of plating, are to extend throughout the cargo tanks.

4402 The scantlings of bilge longitudinals are to be graduated between those required for the bottom and lowest side longitudinals.

4403 Where flat bars are used for longitudinals the thickness is not to be less than one-fifteenth of the depth.

Connections

4404 End connections of longitudinals to bulkheads are to provide adequate fixity and, so far as practicable, direct continuity of longitudinal strength.

4405 Where the length exceeds 700 feet it is desirable that the bottom and deck longitudinals be continuous through the transverse bulkheads but alternative arrangements will be specially considered.

4406 Longitudinals are to be connected to the transverses as required by Table 63E. In ships above 650 feet all longitudinals (including those on longitudinal bulkheads) are to have the web attached to the transverses. In ships between 500 feet and 650 feet, similar arrangements are to be made except that side longitudinals and longitudinal bulkhead horizontal stiffeners need not have the webs attached unless they are within 10 feet of the bottom or deck.

Section 45

TRANSVERSE SIDE FRAMING

Scantlings

4501 Where, in tankers not exceeding 650 feet in length, transverse side framing is adopted in the cargo tanks, the section modulus of side frames is not to be less than:—

$\frac{I}{y} = \frac{s \times h \times S^2}{2220}$ inches^3 where side transverses are fitted,

or $\frac{I}{y} = \frac{s \times h \times S^2}{1890}$ inches^3 where side transverses are not fitted,

where s = frame spacing in inches,

h = head in feet from mid-point of span to deck at side measured at mid-length of tank,

S = span in feet measured between stringers or from stringer to "span point".

The size of the frame is to be governed by the maximum modulus derived from the above formula and is to be maintained for the full depth of the ship. The modulus given is that of the frame and associated side shell plating. (*See* D 5301.)

Side Stringers

4502 Where the depth D does not exceed 25 feet, one side stringer is to be fitted. Where D exceeds 25 feet but does not exceed 35 feet, 2 stringers are required and over 35 feet depth, 3 stringers. For scantlings of stringers *see* D 4702.

Side Transverses

4503 Where the depth exceeds 35 feet, side transverses are to be fitted in line with the bottom transverses. The scantlings of the side transverses are to be determined in accordance with D 4606.

Connections and End Attachments

4504 Side frames are to be connected to the side stringers as required by Table 63E.

4505 The brackets at the upper end of side frames are to be as shown in Table 63F.

4506 Side frames are to be efficiently connected at the lower end to stiffened brackets covering the entire round of bilge and extending at least to the first bottom longitudinal. The thickness of the bracket is to be the same as that of the transverses in the wing tank.

Section 46

BOTTOM, SIDE AND DECK TRANSVERSES

General

4601 The spacing of transverses is generally not to exceed 12 feet when the length L is 600 feet or less, or 16 feet when L is 800 feet or over with spacings at intermediate lengths in proportion. Where, however, the longitudinal bulkhead is corrugated, the spacing of transverses is generally not to exceed 14 feet.

Bottom Transverses

4602 The section modulus of the transverses is not to be less than:—

$$\frac{I}{y} = \frac{s \times D}{6}(S-5) \text{ inches}^3 \text{ where the span does not exceed 33 feet,}$$

$$\text{or } \frac{I}{y} = \frac{s \times D \times S^2}{233} \text{ inches}^3 \text{ where the span exceeds 33 feet,}$$

where s = spacing of transverses, in feet,

S = span of transverses in feet from "span point" to "span point" (minimum value 9 feet),

D = moulded depth, in feet.

Where the bottom centre line girder is intercostal between the transverses the modulus derived as above is to be increased by 10 per cent.

4603 If intercostal side girders are fitted, and their scantlings are in accordance with D 4809, the modulus of the bottom transverses derived in accordance with either of the preceding formulæ may be reduced by 5 per cent.

4604 The depth of the bottom transverse is not to be less than either one-fifth of its span or $2\frac{1}{2}$ times the depth of the slot for the bottom longitudinal, whichever is the greater.

4605 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

Side Transverses

4606 The section modulus of side transverses not supported by cross ties is not to be less than:—

$$\frac{I}{y} = \frac{s \times h}{3{\cdot}9}(S-5) \text{ inches}^3 \text{ where the span does not exceed 33 feet,}$$

$$\text{or } \frac{I}{y} = \frac{s \times h \times S^2}{150} \text{ inches}^3 \text{ where the span exceeds 33 feet.}$$

Side transverses supported by cross ties are to have a section modulus not less than that given by the following formulæ:—

Number of Cross Ties	Section Modulus Inches³
1	$\frac{s}{8}\left[(D-24)^2+78\right]$
2	$\frac{s}{10}\left[(D-24)^2+78\right]$
3	$\frac{s}{12}\left[(D-24)^2+78\right]$
4	$\frac{s}{13{\cdot}5}\left[(D-24)^2+78\right]$
1 horizontal and 2 diagonal meeting at side transverse	$\frac{s}{9}\left[(D-24)^2+78\right]$

In the above

s = spacing of transverses in feet,

h = head from mid-point of span to deck at side, in feet,

S = span of transverse in feet from "span point" to "span point",

D = moulded depth in feet.

4607 If side transverses are tapered, the increase in depth at the bottom, and decrease at the top, is not to exceed 10 per cent of the mean depth.

4608 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

Deck Transverses

4609 The section modulus of deck transverses is not to be less than that given by the formula

$$\frac{I}{y} = (\cdot 0025\, s\, L + 0{\cdot}8)(S+6) \text{ inches}^3,$$

where s = spacing of transverses in feet,

L = length of ship in feet,

S = span of transverse in feet from "span point" to "span point".

4610 If intercostal side girders are fitted, and their scantlings are in accordance with D 4814, the modulus of the deck transverses derived in accordance with the above formula may be reduced by 5 per cent.

4611 The depth of the deck transverse is not to be less than one sixth of its span or $2\frac{1}{2}$ times the depth of the slot for the deck longitudinal, whichever is the greater.

4612 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of deck plating *see* D 5305.

Section 47

SIDE STRINGERS

General

4701 Where transverse side framing is adopted, side stringers are to be fitted as required by D 4502.

Scantlings

4702 The modulus of side stringers is not to be less than given by the following formulæ:—

Position of Stringer	Section Modulus Inches^3
Single	$\frac{b \times h \times S^2}{140}$
Upper of two or more	$\frac{b \times h \times S^2}{110}$
Middle or lower	$\frac{b \times h \times S^2}{140}$

where b = width of plating supported, in feet.
Where applicable, the width supported is to be taken as half the distance from the next stringer to the deck at side or base line as appropriate,

h = head from stringer to highest point of tank, excluding hatchway,

S = span from "span point" to "span point" or from "span point" to side transverse, in feet (minimum value to be taken as 10 feet).

4703 The depth of the stringer is not to be less than $2\frac{1}{2}$ times the depth of the slot for the frame.

4704 Where side transverses are not fitted the lower side stringers are to be supported by suitable buttress brackets from the bottom transverses.

4705 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of transverses of various depths, face areas and thicknesses of shell plating *see* D 5305.

Section 48

BOTTOM AND DECK GIRDERS

Bottom Centre Line Girder

4801 When the length L exceeds 550 feet and a centre line bulkhead is not fitted, the bottom transverses are to be supported by a centre line girder continuous between transverse bulkheads. The section modulus of the girder is not to be less than:—

$$\frac{I}{y} = \cdot 16\ b\ D\ (S-2) \text{ inches}^3,$$

where b = half breadth of centre tank, in feet, or, where there is a vertical web on the inboard side of the longitudinal bulkheads, half the distance between the faces of the webs.

D = moulded depth, in feet,

S = distance in feet from "span point" to "span point".

4802 Where intercostal side girders, having scantlings as required by 4809, are fitted in the centre tank, the section modulus of the centre girder derived in accordance with 4801 may be reduced by 5 per cent.

4803 Where the length L does not exceed 550 feet the centre line girder may be continuous between transverse bulkheads and have scantlings as required by 4801 or may be intercostal between transverses and effectively connected to the transverses and bulkheads. An intercostal girder is to have a section modulus not less than :—

$$\frac{I}{y} = \frac{B \times D \times s}{40} \text{ inches}^3,$$

where B = moulded breadth, in feet,

D = moulded depth, in feet,

s = spacing of transverses, in feet.

4804 The depth of an intercostal girder is not to exceed the depth of the transverses.

4805 Vertical webs are generally to be arranged on the transverse bulkheads in association with continuous or intercostal bottom centre line girders.

4806 Flanged or otherwise stiffened brackets are to be fitted on both sides of the girder mid-way between the transverses with intermediate vertical stiffeners not more

than 3 feet 3 inches apart. The brackets are to be connected to a suitable bottom longitudinal. In deep centre line girders horizontal stiffening is to be arranged and the brackets on one side may stop at a suitable horizontal stiffener. The intermediate vertical stiffeners may be omitted but where the spacing of brackets exceeds 6 feet an intermediate vertical stiffener is to be fitted to the lower part of the girder.

4807 The thickness of the centre girder is not to be less than 10 per cent thicker than that given in D 5309 unless suitable horizontal stiffening is arranged.

Bottom Side Girders

4808 Continuous or intercostal side girders are generally to be arranged in the centre and wing tanks in ships exceeding 700 feet in length. The girders are to be arranged in line with vertical webs on the transverse bulkheads and below the deck to form a ring system.

4809 The section modulus is not to be less than:—

$$\frac{I}{y} = \frac{S^2 \times b_1 \times D}{100} \text{ inches}^3,$$

where S = span measured from transverse to transverse, in feet,

b_1 = half breadth of centre tank (or breadth of wing tank) divided by the number of side girders plus one. (The number of side girders is to be that in the half breadth of centre tank or breadth of wing tank as appropriate),

D = moulded depth, in feet.

4810 The depth of the side girder is not to be less than 50 per cent of the depth of the bottom transverse and is to be efficiently bracketed thereto.

4811 For reduction to modulus of centre girder and bottom transverses when side girders are fitted in accordance with 4809, *see* 4802 and D 4603.

Deck Centre Line Girder

4812 A continuous deck centre line girder is to be fitted having a section modulus not less than:—

$$\frac{I}{y} = \frac{l^2 \times b \times L}{20000} \text{ inches}^3,$$

where l = length of centre tank, in feet,

b = half-breadth of centre tank, in feet, or, where there is a vertical web on the inboard side of the longitudinal bulkheads, half the distance between the faces of the webs,

L = length of ship, in feet.

4813 Where intercostal side girders, having scantlings as required by 4814, are fitted in the centre tank the section modulus of the deck centre girder derived in accordance with 4812 may be reduced by 5 per cent.

Deck Side Girders

4814 Side girders as required by 4808 are to have a depth not less than 50 per cent of the depth of the deck transverse. The face area is not to be less than that of the transverses.

4815 For reduction to modulus of deck centre girder and deck transverses when side girders are fitted, *see* 4813 and D 4610.

General

4816 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of girders of various depths, face areas and thicknesses of shell or deck plating *see* D 5305.

Section 49

CROSS TIES

4901 Cross ties may be of plate or sectional material and are to have an area and least moment of inertia not less than:—

$$A = 10 + \frac{l \times h \times s}{220} \text{ inches}^2,$$

$$I = \frac{l \times h \times s \times S^2}{6500} \text{ inches}^4,$$

where l = one half the distance in feet between the centre of the adjacent cross ties or between the centre of the adjacent cross tie and the centre of the bottom or deck transverse,

h = vertical distance in feet from the centre of the cross tie to deck at side amidships,

s = spacing of transverses, in feet,

S = length of cross tie between the toes of the horizontal tripping brackets on the transverse webs at the cross ties. Special consideration will be given where alternative arrangements omitting the tripping brackets are provided.

Diagonal cross ties will be specially considered but, in general, the area and least moment of inertia of the horizontal cross tie is not to be less than 85 per cent of that required

by the above formula assuming the centre cross tie only is fitted. The area of each diagonal cross tie is not to be less than 85 per cent of that required for the horizontal cross tie.

4902 Cross ties are to be connected to the vertical transverses or horizontal girders by suitable brackets. Tripping brackets are to be fitted to the transverses in way of the cross ties and where scallops for longitudinals or frames come in way of the cross ties they are to be closed by plate collars.

4903 Cross ties are to be provided with suitable horizontal stiffening to prevent buckling and twisting. Where the unsupported width of face plate exceeds 6 inches, additional vertical stiffening is to be arranged to support the face plate.

Section 50

OILTIGHT AND NON-OILTIGHT BULKHEADS

OILTIGHT BULKHEADS

General

5001 Longitudinal bulkheads, other than at the centre line, are to be oiltight throughout the cargo tanks and may be plane or horizontally corrugated.

Where a centre line bulkhead is required by D 4003 or D 4008 it may be oiltight or perforated.

Longitudinal bulkheads may be perforated in pump rooms or cofferdams, provided suitable compensation is arranged.

When a wash bulkhead is fitted, the length or breadth of a tank may, for the purposes of 5012, 5013, 5025 and 5026, be measured from the wash bulkhead to the oiltight bulkhead.

5002 Where the ship's side is framed longitudinally the stiffening on the longitudinal bulkheads is to be arranged horizontally. Vertical stiffening may be adopted in association with transverse side framing.

5003 Transverse bulkheads may be plane or with corrugations arranged horizontally or vertically.

5004 The scantlings of cofferdam bulkheads not forming the boundary of a cargo tank are to be as required by D 20 for oil fuel deep tanks.

Where a pump room acts as a cofferdam, a bulkhead which does not form part of the boundary of a cargo tank or an oil fuel bunker may be of watertight bulkhead scantlings in accordance with D 16 except that, in a riveted bulkhead, the riveting is to be as required for an oiltight bulkhead.

5005 Beyond the ends of the oil tanks the longitudinal bulkheads are to scarph into the adjoining structure.

PLANE BULKHEADS

Plating

5006 The thickness of the plating is not to be less than

$$t = \left(0{\cdot}31+\frac{h}{200}\right)\frac{s}{30} \text{ inches,}$$

except that the thickness of the top and bottom strakes of longitudinal bulkheads is in no case to be less than:—

$$\text{Top strake} \quad t = \left(0{\cdot}22+\frac{L}{2000}\right)\frac{s}{30} \text{ inches,}$$

$$\text{Bottom strake} \quad t = \left(0{\cdot}28+\frac{L}{2000}\right)\frac{s}{30} \text{ inches,}$$

where h = distance in feet from lower edge of plate to highest point of tank, excluding the hatchway,

s = spacing of stiffeners, in inches,

L = length of ship, in feet.

The breadth of the top and bottom strakes of longitudinal bulkheads is not to be less than ·1D.

For minimum thickness *see* D 5308.

Where the breadth B exceeds 105 feet and a centre line bulkhead is not required by D 4003 or D 4008 the thickness of the plating of the side longitudinal bulkheads is to be increased as follows:—

Breadth B	*Increase*
Exceeding 105 feet and not exceeding 110 feet ...	3 per cent per foot excess over 105 feet
Exceeding 110 feet ...	15 per cent

Stiffeners

5007 The section modulus of horizontal or vertical stiffeners is not to be less than:—

$$\frac{I}{y} = \frac{s\,S^2}{2680}(h+3) \text{ inches}^3$$

where s = spacing in inches,

S = span in feet measured between girders or from girder to "span point",

h = distance in feet from centre of span to highest point of tank, excluding the hatchway.

The section modulus given by this formula is that of the stiffener and associated plating. (*See* D 5301.)

5008 The modulus of horizontal stiffeners on longitudinal bulkheads is not to be less than 90 per cent of the modulus of the uppermost side longitudinal.

5009 The modulus of vertical stiffeners on longitudinal or transverse bulkheads may be reduced by 10 per cent where vertical webs are fitted.

5010 Stiffeners are to be bracketed or otherwise efficiently connected at their ends to provide adequate fixity and, for horizontal stiffeners, continuity of longitudinal strength at the bulkheads.

The end brackets of longitudinal bulkhead vertical stiffeners are to be as required by Table 63F and are to be connected to a suitable longitudinal or are to be well hollowed and tapered.

All stiffeners are to be connected to the supporting webs or girders as required by Table 63E.

The plating is to be efficiently stiffened to support loads transmitted by end connections of longitudinal bulkhead, shell and deck longitudinals and the like.

Webs and Girders

5011 The section modulus of vertical webs and horizontal girders is not to be less than that required by the appropriate formula below:—

Item	Section Modulus Inches^3
1. VERTICAL WEBS (other than in (2) below)	
(a) On transverse bulkheads not forming a ring system but including the web on the centre line.	$\frac{b \times h \times S^2}{150}$
(b) On transverse bulkheads forming a ring system* (other than at centre line) as primary supporting members and supporting horizontal stiffeners.	$\frac{b \times h \times S^2}{190}$
(c) On longitudinal bulkheads	90 per cent of side transverse
2. INTERCOSTAL VERTICAL WEBS ON TRANSVERSE BULKHEADS NOT SUPPORTING STIFFENERS	$\frac{b_1 \times h \times S^2}{275}$
3. HORIZONTAL GIRDERS ON LONGITUDINAL OR TRANSVERSE BULKHEADS	
(a) Single girder	$\frac{b \times h \times S^2}{160}$
(b) Upper of two or more	$\frac{b \times h \times S^2}{130}$
(c) Middle or lower	$\frac{b \times h \times S^2}{160}$

* i.e., in association with bottom and deck girders of Rule scantlings.

In the above:—

b = width of plating supported, in feet,

h = distance in feet from centre of span to highest point of tank, excluding hatchway,

S = span in feet from "span point" to "span point".

For horizontal girders on longitudinal bulkheads a minimum value of 10 feet is to be used.

For intercostal vertical webs not supporting stiffeners (item 2 in above Table) b_1 is to be taken as half the breadth of centre tank (or the breadth of wing tank) divided by the number of webs plus one (number of webs to be those in the half breadth of centre tank or breadth of wing tank as appropriate) and S is to be measured between girders or from girder to span point. The maximum value of $\frac{b_1 \times h \times S^2}{275}$ is to be used for the full depth of bulkhead.

5012 Where the length of a cargo tank exceeds 45 feet the section modulus of vertical webs and horizontal girders on the transverse bulkheads is to be increased at the rate of 2 per cent per foot excess above 45 feet. (*See also* 5001.)

5013 Where the breadth of a cargo tank exceeds 45 feet the section modulus of the vertical webs and horizontal girders on the longitudinal bulkhead is to be increased at the rate of 2 per cent per foot excess above 45 feet. (*See also* 5001.)

5014 Where side transverses are required by D 4503, vertical webs are to be fitted on the longitudinal bulkhead. Where vertical webs are not fitted, the lower horizontal girders are to be supported by suitable buttress brackets from the bottom transverses.

5015 The depth of a girder or web is not to be less than $2\frac{1}{2}$ times the depth of the slot for the stiffener.

For minimum thicknesses *see* D 5308 and D 5309.

For moduli of webs and girders of various depths, face areas and bulkhead plating *see* D 5305.

5016 The end attachments of vertical webs and horizontal girders are to have a length of arm at least equal to the depth of web.

CORRUGATED BULKHEADS

General

5017 Where corrugated bulkheads are adopted the corrugations should be arranged in accordance with 5001 and 5003.

5018 In ships above 600 feet in length the upper and lower strakes of the longitudinal bulkhead are to be plane for a distance of ·1D from the deck and bottom and the vertical webs are to be arranged symmetrically on each side of the longitudinal bulkhead. Alternative arrangements with unsymmetrical webs will be specially considered, having in view the spacing of transverses and the type of transverse bulkhead, etc.

Plating

5019 The thickness of the plating is not to be less than

$$t = \left(0{\cdot}31+\frac{h}{200}\right)\frac{s}{30} \text{ inches}$$

where h = distance in feet from lower edge of plate to highest point of tank, excluding hatchway,

s = width of panel in inches (flat or inclined surface, i.e., b or c in the figure in 5020, whichever is the greater). A minimum value of 30 is to be used in this formula.

When s exceeds 33 inches the scantlings will be specially considered.

For minimum thickness see D 5308.

The thickness of the top and bottom strakes of longitudinal bulkheads is not to be less than required by 5006.

The thickness of plating is also to be such that the requirements of 5020 are satisfied.

5020 The minimum angle of corrugation is to be 40° and the dimensions of the corrugations are to fulfil the following two conditions:—

(1) $\frac{t\ d\ (3\ b+c)}{p}$ not to be less than $\frac{h\ S^2}{385}$

(2) $\frac{t\ d^2\ (3\ b+c)}{p}$ not to be less than $\frac{h\ S^3}{315}$

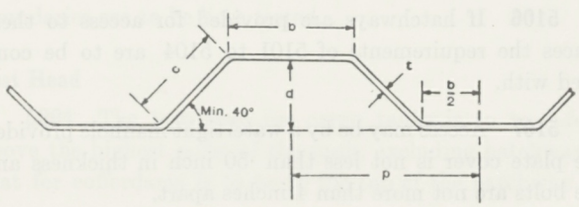
except that when a vertically corrugated transverse bulkhead is supported by two or more horizontal girders $\frac{h\ S^3}{420}$ may be substituted for $\frac{h\ S^3}{315}$ in (2) for the portion between the girders.

In the above:—

h = distance, in feet, from centre of span to highest point of tank, excluding hatchway,

S = span of corrugation, in feet, measured from girder to girder, transverse to transverse or side, bottom, deck or bulkhead to transverse or girder,

and t, b, c, d and p are as shown in the sketch below.



In (1) and (2) above the value of b is not to be taken as greater than 50 t. Where unsymmetrical girders or webs are fitted to corrugated bulkheads, the maximum angle of corrugation is to be 60°.

5021 Corrugations are to be in line, and of the same form, on each side of bulkheads, horizontal girders and vertical webs.

Webs and Girders

5022 Horizontal girders and vertical webs are to be arranged to support the corrugations so that the span of the corrugated bulkhead does not exceed 16 feet, except that the top span of a vertically corrugated bulkhead may be 17 feet. (For vertical webs on longitudinal bulkheads *see also* D 4601.)

5023 The section modulus of vertical webs and horizontal girders is not to be less than that required by the appropriate formula below:—

Item	Section Modulus inches³
1. Vertical Webs	
(a) On Vertically Corrugated Bulkheads	
At centre line	$\frac{b\times h\times S^2}{150}$
Other webs forming a ring system* and not supporting girders	$\frac{b_1\times h\times S^2}{275}$
(b) On Horizontally Corrugated Bulkheads	
(i) Transverse bulkheads: At centre line	$\frac{b\times h\times S^2}{150}$
Other webs forming a ring system*	$\frac{b\times h\times S^2}{190}$
Webs not forming a ring system	$\frac{b\times h\times S^2}{150}$
(ii) Longitudinal bulkheads	90 per cent of side transverse
2. Horizontal Girders on Vertically Corrugated Transverse Bulkheads	
(a) Single girder	$\frac{b\times h\times S^2}{160}$
(b) Upper of two or more	$\frac{b\times h\times S^2}{130}$
(c) Middle or lower	$\frac{b\times h\times S^2}{160}$

* i.e., in association with bottom and deck girders of Rule scantlings.

In the above:—

b = width of plating supported, in feet,

h = distance in feet from centre of span to highest point of tank, excluding hatchway,

S = span in feet from "span point" to "span point".

For vertical webs forming a ring system and not supporting girders, b_1 is to be taken as half the breadth of the centre tank (or breadth of wing tank) divided by the number of webs plus one and S is to be measured between girders or from girder to span point. The maximum value of $\frac{b_1 \times h \times S^2}{275}$ is to be used for the full depth of bulkhead.

5024 Where webs or girders are symmetrical on each side of a corrugated bulkhead the section modulus derived as above may be reduced by 10 per cent.

5025 Where the length of a cargo tank exceeds 45 feet the section modulus of vertical webs and horizontal girders on the transverse bulkheads is to be increased at the rate of 2 per cent per foot excess above 45 feet. (*See also* 5001.)

5026 Where the breadth of a cargo tank exceeds 45 feet the section modulus of the vertical webs on the longitudinal bulkhead is to be increased at the rate of 2 per cent per foot excess above 45 feet. (*See also* 5001.)

5027 For minimum thicknesses *see* D 5308 and D 5309.

For moduli of webs and girders of various depths, face areas and bulkhead plating *see* D 5305.

5028 The end attachments of vertical webs and horizontal girders are to have a length of arm at least equal to the depth of web.

NON-OILTIGHT BULKHEADS (PLANE OR CORRUGATED)

5029 Wash bulkheads and perforated centre line longitudinal bulkheads are to have an area of perforations not less than 5 per cent of the total area of the bulkhead. Special care is to be taken to ensure that a perforated centre line longitudinal bulkhead provides an efficient connection between the deck and bottom plating.

The lower part of the centre line bulkhead is to be strongly constructed to act as a bottom centre line girder in order to withstand the forces on the keel when the ship is in dry dock.

5030 The modulus of stiffeners, webs and girders should be at least 50 per cent of that required for an oiltight bulkhead. The depth of webs and girders is to be at least $2\frac{1}{2}$ times the depth of the slot for the stiffener.

5031 The thickness of plating may be the compartment minimum (*see* D 5308) except that the top and bottom strakes of a centre line bulkhead are to be as required for an oiltight longitudinal bulkhead.

Section 51

HATCHWAYS

Oiltight Hatchways

5101 Oiltight hatchways are to be kept to the minimum size required to provide reasonable access and ventilation to each compartment.

Corners of hatchway openings are to be well rounded and smooth.

5102 The height of the coaming is not to be less than 10 inches. Coaming plates not exceeding 32 inches in height are not to be less than ·40 inch in thickness.

5103 Where the area of the hatchway cover does not exceed 12 square feet in a circular hatchway, or 16 square feet in a rectangular hatchway, the thickness of the cover is to be ·50 inch.

If the area exceeds the above but does not exceed 25 square feet the thickness of the cover is to be ·60 inch or may be ·50 inch if stiffened by 4-inch flats spaced 24 inches apart.

5104 Covers are to be secured by fastenings spaced not more than 18 inches apart in a circular hatchway or 15 inches apart in a rectangular hatchway and not more than 9 inches from the corners.

Hatchway covers of special design with alternative methods of closing will be specially considered.

Ullage Plugs and Tank Cleaning Openings

5105 Ullage plugs or sighting ports are not to be arranged in enclosed spaces. Tank cleaning openings should, wherever practicable, be arranged on the open deck.

Access to Cofferdams, Dry Tanks or Water Ballast Tanks

5106 If hatchways are provided for access to these spaces the requirements of 5101 to 5104 are to be complied with.

5107 Access may be by a watertight manhole provided the plate cover is not less than ·50 inch in thickness and the bolts are not more than 4 inches apart.

Hatchways to Spaces other than Oil Tanks, Cofferdams, Dry Tanks, or Water Ballast Tanks

5108 Hatchways are to be constructed in accordance with the requirements of D 23 except that efficient steel watertight covers are to be fitted to hatchways situated on expansion trunks and on the strength deck, either where exposed or inside open superstructures.

Hatchways situated on the forecastle deck are to have steel covers except where efficient steel watertight covers are fitted to the hatchways inside the forecastle.

Section 52

TESTING

General

5201 Each cargo tank and cofferdam is to be separately tested by filling with water to the test head.

Where the complete water testing on the building berth or in drydock may be undesirable, final testing may be carried out afloat provided the bottom and lower side shell are tested on the building berth or in drydock by filling the tanks to about half the depth of the tank. The final testing afloat is to be carried out by separately filling each tank and cofferdam to the test head. With about half the tanks full, the bottom and lower side shell in the empty tanks is to be examined and the remainder of the bottom and lower side shell examined when the water is transferred.

Where a preservative coating is to be applied to the internal structure of a tank before water testing, the tank is to be tested by an air pressure of 4 lb. per square inch prior to the application of the preservative. Precautions are to be taken to ensure that this pressure is not exceeded.

The final water testing, which may take place after the application of the preservative, is to be carried out by separately filling each compartment to the test head.

5202 Water ballast and dry tanks should be tested as required for cargo tanks.

5203 It is recommended that pump rooms be flooded to a suitable depth prior to launch. The bottom and side shell plating is to be carefully examined internally with the vessel at a deep draught. Bulkheads not forming tank boundaries are to be hose tested.

Test Head

5204 The test head for cargo tanks is to be 8 feet above the highest point of the tank, excluding hatchways; that for cofferdams is to be to the top of the hatchway.

Bunkers and Deep Tanks

5205 Bunkers and deep tanks are to be tested as required by D 2030 and D 1914 respectively.

Section 53

EFFECTIVE SECTION MODULUS, FACE AREAS AND MINIMUM THICKNESSES

EFFECTIVE SECTION MODULUS

Longitudinals, Frames and Stiffeners

5301 For longitudinals, side frames and bulkhead stiffeners the section modulus required by the appropriate formula is to be that of the section in association with 24 inches of plating having the same thickness as the shell, deck or bulkhead plating as appropriate. Where the attached plating is of varying thickness, the mean thickness over the appropriate span is to be used.

The effective section moduli of rolled sections and the area of the section without plating are given in the publication "Geometric Properties of Rolled Sections and Built Girders".

The effective section moduli of flat bars or built sections may be obtained from curves in the above publication.

Transverses, Webs, Stringers and Girders

5302 For transverses, webs, stringers and girders, the section modulus required by the appropriate formula is to be that of the member in association with an effective area of shell, deck or bulkhead plating.

5303 Except for corrugated bulkheads, the effective area is to be:—

$$A = 12\ k\ b\ t_p \text{ square inches,}$$

where k = a coefficient obtained from the table below,

b = actual width in feet of load-bearing plating, i.e., one half the sum of spacings of parallel adjacent members of greater or equivalent length (*see* sketches on pages 202 and 203),

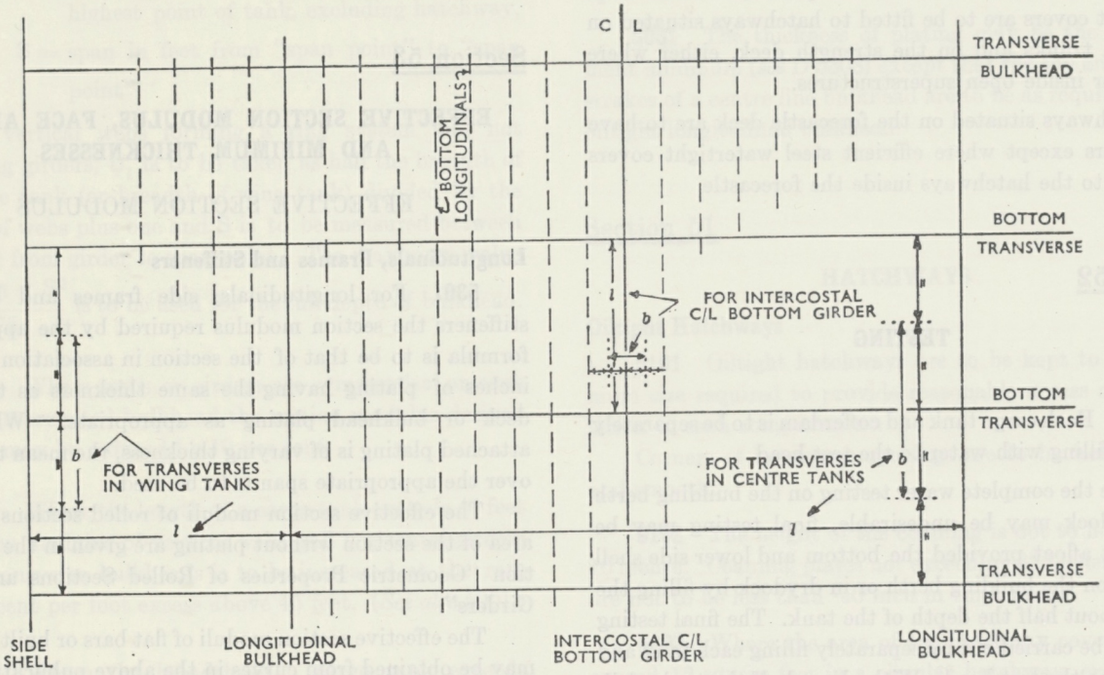
t_p = mean thickness of attached shell, deck or bulkhead plating in inches,

l = overall length of girder, transverse, etc., in feet (*see* sketches on pages 202 and 203).

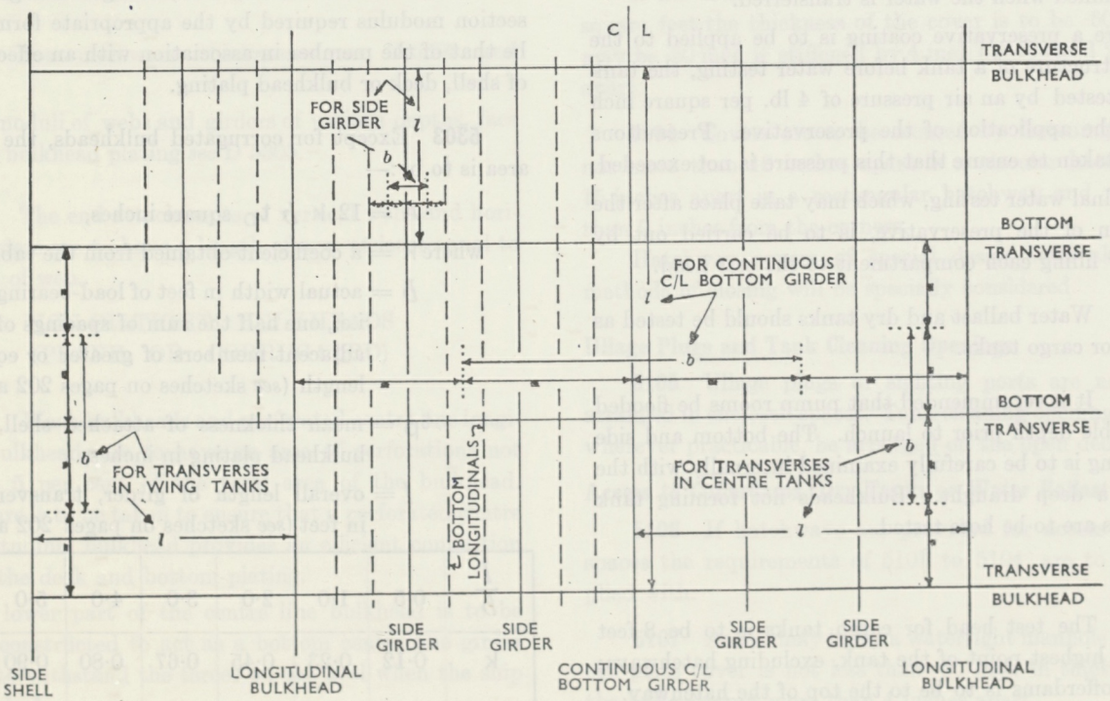
$\frac{l}{b}$	0·5	1·0	2·0	3·0	4·0	5·0	6·0
k	0·12	0·23	0·45	0·67	0·80	0·90	1·00

TO ILLUSTRATE PARAGRAPH D 5303

(a) BOTTOM STRUCTURE WITH INTERCOSTAL BOTTOM CENTRE-LINE GIRDER

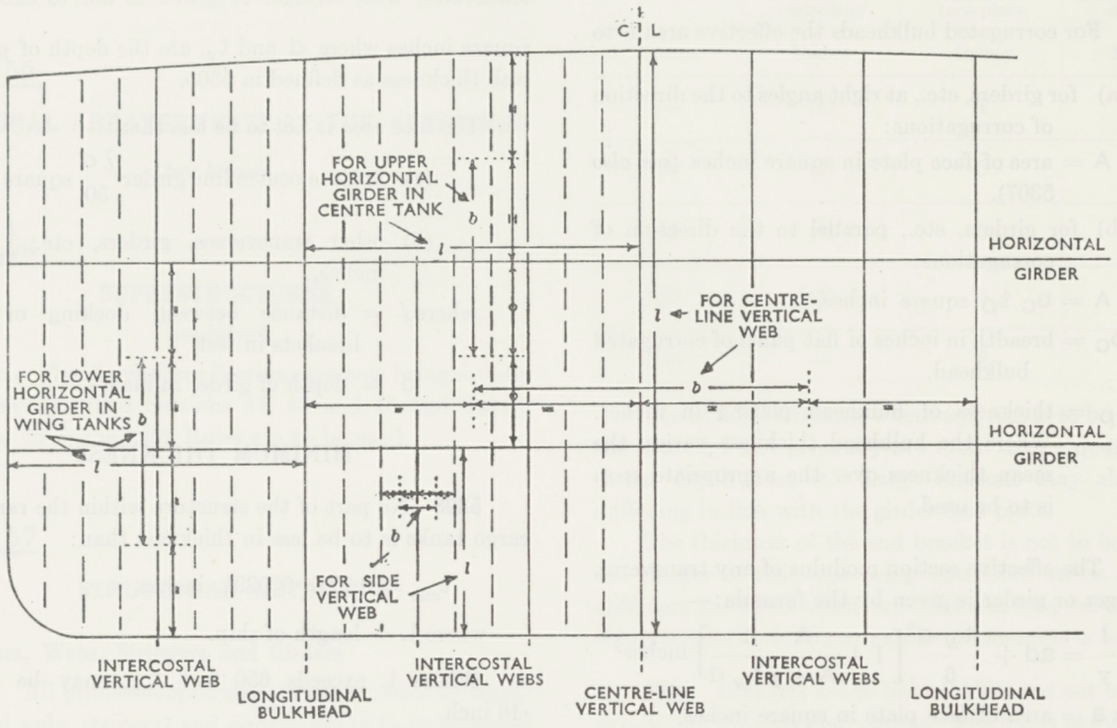


(b) BOTTOM STRUCTURE WITH CONTINUOUS BOTTOM CENTRE-LINE GIRDER

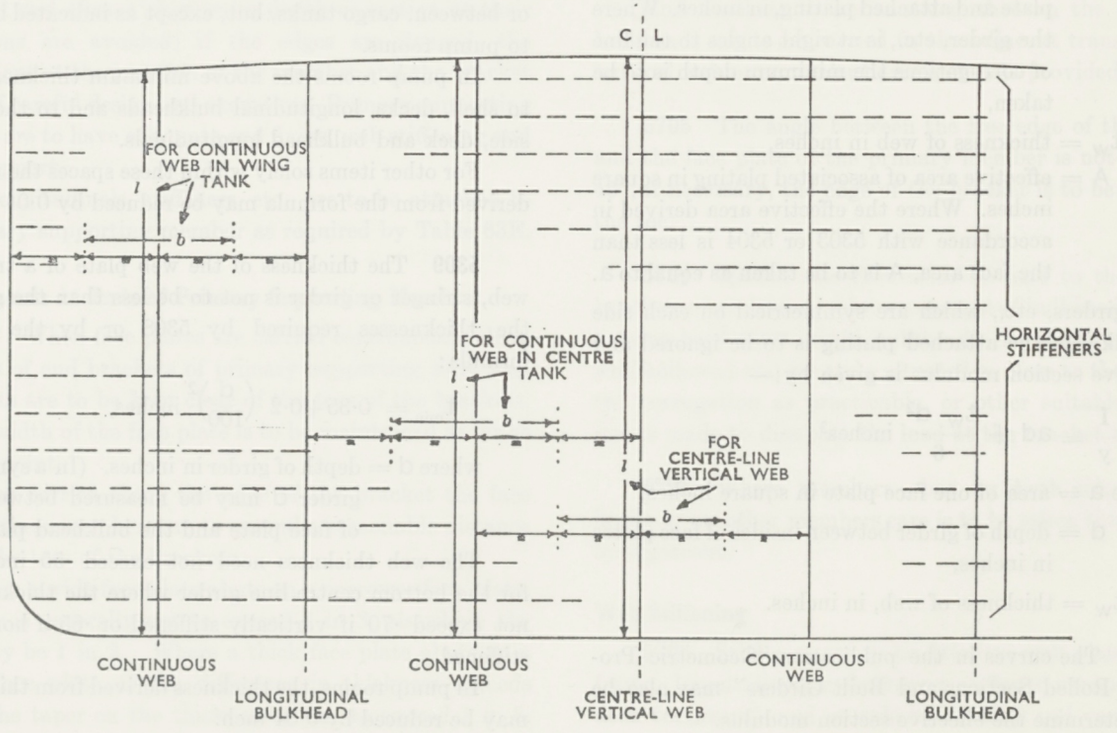


TO ILLUSTRATE PARAGRAPH D 5303

(c) TRANSVERSE BULKHEAD WITH VERTICAL STIFFENING



(d) TRANSVERSE BULKHEAD WITH HORIZONTAL STIFFENING



For intermediate values of $\frac{l}{b}$, k is to be obtained by interpolation. Where $\frac{l}{b}$ exceeds 6·0, k is to be taken as 1·0.

5304 For corrugated bulkheads the effective area is to be:—

(a) for girders, etc., at right angles to the direction of corrugations:

A = area of face plate in square inches (*see also* 5307).

(b) for girders, etc., parallel to the direction of corrugations:

$A = b_c\ t_p$ square inches,

where b_c = breadth in inches of flat panel of corrugated bulkhead,

t_p = thickness of bulkhead plating in inches. Where the bulkhead thickness varies, the mean thickness over the appropriate span is to be used.

5305 The effective section modulus of any transverse, web, stringer or girder is given by the formula:—

$$\frac{I}{y} = ad + \frac{t_w\ d^2}{6}\left[1 + \frac{A - a}{A + \frac{1}{2}\ t_w\ d}\right] \text{ inches}^3$$

where a = area of face plate in square inches,

d = depth of girder, etc., between inside of face plate and attached plating, in inches. Where the girder, etc., is at right angles to the line of corrugations the minimum depth is to be taken,

t_w = thickness of web in inches,

A = effective area of associated plating in square inches. Where the effective area derived in accordance with 5303 or 5304 is less than the face area, A is to be taken as equal to a.

For girders, etc., which are symmetrical on each side of the bulkhead the attached plating is to be ignored and the effective section modulus is given by:—

$$\frac{I}{y} = ad + \frac{t_w\ d^2}{6} \text{ inches}^3$$

where a = area of one face plate in square inches,

d = depth of girder between insides of face plates in inches,

t_w = thickness of web, in inches.

5306 The curves in the publication "Geometric Properties of Rolled Sections and Built Girders" may also be used to determine the effective section modulus.

MAXIMUM AND MINIMUM FACE AREAS

5307 The area of material in the face plate of any transverse, web, stringer or girder is not to exceed $\frac{d\ t_w}{1{\cdot}5}$ square inches where d and t_w are the depth of girder and web thickness as defined in 5305.

The face area is not to be less than:—

(a) bottom centre line girder $\frac{l\ d}{50}$ square inches,

(b) other transverses, girders, etc., $\frac{l\ d}{200}$ square inches,

where l = distance between docking or tripping brackets in feet,

d = depth of girder in inches.

MINIMUM THICKNESS

5308 No part of the structure within the range of the cargo tanks is to be less in thickness than:

$$t_{min} = 0{\cdot}27 + {\cdot}00029L \text{ inches},$$

where L = length of ship.

Where L exceeds 650 feet t_{min} may be taken as ·46 inch.

This minimum also applies to cofferdams at the ends of, or between, cargo tanks, but, except as indicated below, not to pump rooms.

In pump rooms the above minimum thickness applies to shell, decks, longitudinal bulkheads and to the bottom, side, deck and bulkhead longitudinals.

For other items solely within these spaces the minimum derived from the formula may be reduced by 0·04 inch.

5309 The thickness of the web plate of a transverse, web, stringer or girder is not to be less than the greater of the thicknesses required by 5308 or by the following formula:

$$t_{min} = 0{\cdot}35 + 0{\cdot}2\left(\frac{d}{100}\right)^2 \text{ inches},$$

where d = depth of girder in inches. (In a symmetrical girder d may be measured between inside of face plate and the bulkhead plating.)

The web thickness need not exceed ·55 inch except for the bottom centre line girder where the thickness need not exceed ·70 if vertically stiffened or ·65 if horizontally stiffened.

In pump rooms, the thickness derived from this formula may be reduced by 0·04 inch.

Section 54

STRUCTURAL ARRANGEMENTS AT THE FORE END

(see below)

Section 55

STRUCTURAL ARRANGEMENTS AT THE AFTER END

(see below)

Section 56

SUPERSTRUCTURES

(see below)

NOTE.—The above three Sections are now being revised and in the meantime Sections 47, 48 and 45 and Tables 73, 74 and 75 in the 1959 Rules are to be used.

Section 57

STRUCTURAL DETAILS

Transverses, Webs, Stringers and Girders

5701 All primary supporting members, such as transverses and webs, stringers and girders, are to be so arranged that effective continuity of strength throughout their length is ensured and abrupt changes in depth or section at their connections are avoided; if the edges are flanged, the arrangement at the junction of the member and the bracket is to be of careful design and execution. Primary supporting members are to have adequate end fixity, web stiffening and lateral support.

All longitudinals, stiffeners, etc., are to be attached to the primary supporting member as required by Table 63E.

Arrangements at Ends of Primary Supporting Members

5702 When face plates are carried continuously along the edges of end brackets of primary supporting members, their butts are to be kept clear of the toes of the brackets. The full width of the face plate is to be maintained as far as the span point.

If not carried along the edge of the bracket the face plates of these members are to extend a reasonable distance beyond the toes of the brackets.

Where a wide face plate abuts on a narrower face plate, the taper is generally not to exceed 1 in 3, elsewhere the taper may be 1 in 2. Where a thick face plate abuts on a thinner face plate, if the difference in thickness exceeds $\frac{1}{8}$ inch, the taper on the thickness is not to exceed 1 in 3.

5703 End brackets are to be stiffened as follows:—

Length of free edge		Bracket stiffening	
Above	Not exceeding	Flange or face plate	Additional flat stiffener
Inches	Inches	Inches	Inches
—	50	4	—
50	65	5	—
65	80	5	4
80	100	6	4
100	—	8	5

The bracket stiffener, when required, is to be parallel to the free edge and generally not more than a quarter of the throat depth from it. Large brackets may also require stiffening in line with the girder face plate.

The thickness of the end bracket is not to be less than the thicker of the webs being connected unless additional stiffeners are fitted when the thickness may be reduced by ·04 inch, provided the compartment minimum is maintained.

5704 Brackets are to be well hollowed out or attached to a flat on the bulkhead plating. The flat is to extend to an adjacent stiffener or is to be well tapered off.

End brackets to horizontal girders on the transverse bulkheads are to be carried to the adjacent transverse and vertical web or equivalent arrangements provided.

5705 The angle between the free edge of the bracket and the face plate of the primary member is not to exceed 45°; if necessary, the edge of the bracket is to be curved at the toe.

5706 Special attention is to be paid to the tripping brackets of girders or webs on corrugated bulkheads to avoid causing hard spots on the bulkhead. All brackets are to be well hollowed and are to be situated as close to the corner of the corrugation as practicable, or other suitable arrangements made to dissipate the load at the bracket toe.

5707 Where members abut on both sides of bulkheads or on other members care is to be taken that they are in alignment.

Web Stiffening

5708 Stiffeners are to be fitted to web plates at each frame, longitudinal or bulkhead stiffener except that on deck transverses and on side transverses and vertical webs

within ·25D from the deck at side, the stiffeners need only be fitted at alternate longitudinals. Elsewhere the spacing of stiffeners is generally not to be more than 42 inches.

Flat bar stiffeners are to have the depth given in the following Table and minimum compartment thickness. Other types of stiffeners are to be of equivalent inertia.

Depth of Girder		Stiffeners	
Above	Not exceeding		
Inches	Inches	Inches	
—	24	3	Short and long alternately*
24	36	4	Short and long alternately*
36	42	5	Short and long alternately*
42	48	5	All long
48	60	6	All long
60	72	7	All long
72	84	8	All long

* All long in way of end brackets.

Where the depth of the web exceeds 84 inches the stiffening arrangements will be specially considered, taking into account the number of attached girders, etc., and any stiffeners arranged parallel to the face plate of the girder.

Long stiffeners are to extend to the face edge of the web. In way of end brackets, or where required by 5713, the stiffeners are to be attached to the face plate or equivalent arrangements provided.

Short stiffeners are to extend to half the depth of the web but at least beyond the lightening holes or 6 inches beyond the notches.

The requirements of Table 63E as regards area of weld are also to be complied with.

5709 Where bulkheads are horizontally corrugated and the vertical webs are arranged on one side of the bulkhead only, vertical stiffening of the web is to be provided when the depth of the web exceeds 42 inches. The stiffener should be a $6 \times 3\frac{1}{2}$ inch toe welded angle of minimum compartment thickness or equivalent area.

5710 Vertical webs on plane transverse bulkheads are to be stiffened in accordance with 5709 when the depth of web exceeds 76 inches. Similar stiffening may be required on other vertical webs when the depth is excessive.

5711 Stiffeners of the size given in 5708 are generally to be fitted to the deck centre line girder and bottom and deck side girders not more than 42 inches apart. All stiffeners are to extend to the face plate. In deep centre line girders horizontal stiffening is to be arranged.

Lateral Stability

5712 Tripping brackets are to be fitted at suitable intervals. In general, they should be fitted near the toes of end brackets and in way of cross ties. Where the span is long, additional brackets are to be fitted as necessary. In no case is the distance (in feet) between tripping brackets to be greater than:

$$\frac{200 \times a}{d}$$

where a = area of face plate, in square inches

d = depth of girder in inches.

5713 Where the unsupported width of face plate exceeds 6 inches the tripping bracket is to be connected to the face plate. Where, with symmetrically placed face plates, the width of face plate exceeds 16 inches a small bracket connected to the face plate is to be fitted opposite, and in line with, the tripping bracket. Wide face plates may require to be supported between tripping brackets.

Notches

5714 All notches are to have well rounded corners and smooth edges and are not to be larger than necessary. When notches occur at points where stress concentration may develop, such as adjacent to the toes of brackets, a welded collar or equivalent reinforcement is to be fitted. Collars are also to be fitted in way of cross ties.

Lightening, Access, Drain and Air Holes and Holes for Heating Coils, etc.

5715 The diameter of lightening holes is not to exceed 20 per cent of the depth of the web; the edges of the holes should be placed at not less than 40 per cent of the depth of the web from the face and equidistant from the corners of notches for frames or stiffeners. Lightening holes are not to be cut in horizontal girders on the ship's side and longitudinal bulkheads, in symmetrical webs nor in side transverses and vertical webs in way of cross ties and their end connections. Access holes or foot holes may be cut in deep bottom transverses and centre girders with suitable compensation if necessary. All holes are to have smooth edges and are to be kept well clear of notches and the toes of brackets.

5716 Small drain or air holes may be cut in deep framing members and in longitudinals and stiffeners. These

holes should be kept clear of the toes of end brackets and are to be well rounded with smooth edges. (*See also* D 4106 Table 62 Note 4.)

5717 Where holes are cut in the bottom transverses for heating coils the lower edge of the hole is to be not less than 4 inches from the inside of the shell plating.

5718 The edges of all holes in transverses are to be at least 7 inches from the edges of notches for longitudinals.

Welded Connections

5719 The requirements for welded connections and details of scalloped construction are given in Table 63. All scallops are to have well rounded corners and smooth edges. (For general particulars *see* Table 63A.) Scallops are not to be cut in way of end brackets, and scallops in the stiffening members are to be at least 9 inches clear of the toe of the bracket. Scallops in longitudinals, side frames and stiffeners are also to be omitted for at least 9 inches on each side of intersection with a primary supporting member. Scallops are not to be cut in bottom transverses or in horizontal girders on ship's side or longitudinal bulkheads, and in ships over 400 feet in length, scallops are not to be cut in the lower half of side transverses or vertical webs on longitudinal and transverse bulkheads.

Riveted Connections

5720 In riveted construction arrangements are to be generally equivalent to the requirements of this Section and the riveting is to be as required by Table 63.

26th January, 1961.

TABLE 63 A

WELDING AND RIVETING

A

TYPES OF WELDING

SIZE OF FILLET WELDS

PLATE THICKNESS	BASIC LEG LENGTH
Inches	Inches
·20	·22
·30	·26
·40	·30
·50	·34
·60	·38
·70	·44
·80	·50
·90	·56
1·00	·62

NOTES.—TABLE 63 A

1. **Basic leg length** is to be governed by the thickness of the abutting plate or web. Where the difference between the thickness of the parts to be joined is considerable the size of fillet will be specially considered.

2. **Basic leg length** for intermediate thicknesses to be obtained by direct interpolation.

3. **Leg length for double continuous fillets** is the product of Basic Leg Length and the Weld Factor required by Tables 63 G and 63 H.

4. **Leg length for intermittent fillets** is to be given by the formula

   Leg Length = Basic Leg Length × Weld Factor × $\frac{d}{s}$ where s and d are as defined in the sketches below. The length s should not be less than 3 inches and s and d are to be such that the required leg length does not exceed the Basic Leg Length.

5. **Minimum leg length** of fillet weld to be ·80 of the Basic Leg Length except where a reduction is allowed by Notes to Tables 63 E, 63 G and 63 H. In no case is the leg length to be less than ·18 inch.

6. **Throat thickness** of welds is to be 70 per cent of the leg length.

STAGGERED INTERMITTENT

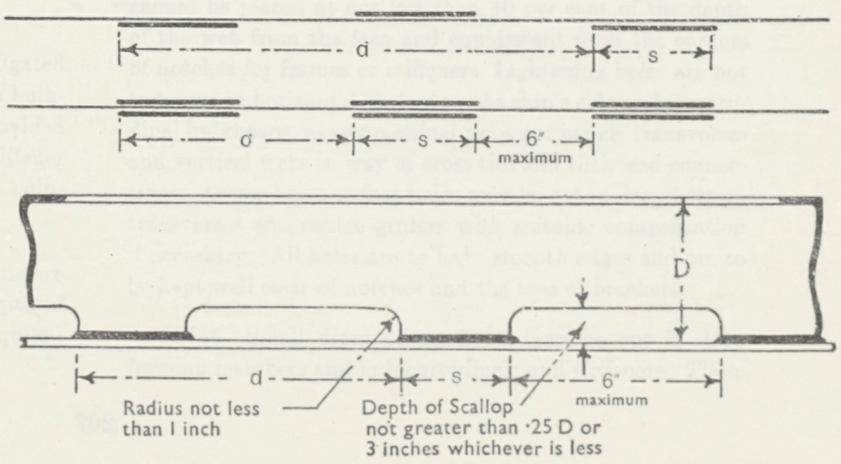
To be doubled at ends. *See* D 3114

CHAIN INTERMITTENT

SCALLOPED FRAMES, LONGITUDINALS, STIFFENERS, etc. WITH DOUBLE FILLET WELDS

Welding to be carried round the ends of all lugs

See also D 5719



WELDING AND RIVETING

B

RIVETING OF SEAMS OF SHELL PLATING

ITEM	THICKNESS		SEAMS			
	Above	Not exceeding	Diameter of rivets	Type	Breadth	Spacing of rivets centre to centre
	Inches	Inches	Inches		Inches	Inches
Sheerstrake between ·25L aft of amidships and ·2L forward of amidships	*See* note 2					
Bottom plating from keel to upper turn of bilge between ·25L aft of amidships and ·2L forward of amidships		·50	$\frac{3}{4}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$
	·50	·72	$\frac{7}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$
	·72	·94	1	Double	6	4
	·94	1·26	$1\frac{1}{8}$	Double	$6\frac{3}{4}$	$4\frac{1}{2}$
	1·26	1·50	$1\frac{1}{8}$	Treble	$9\frac{1}{2}$	$4\frac{1}{2}$
Sheerstrake at ends Side shell plating from upper turn of bilge to sheerstrake Bottom plating from keel to upper turn of bilge at ends		·50	$\frac{3}{4}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$ ^
	·50	·72	$\frac{7}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$ |
	·72	·94	1	Double	6	4 |
	·94	1·14	$1\frac{1}{8}$	Double	$6\frac{3}{4}$	$4\frac{1}{2}$ v
Keel	*See* note 2					

See notes 4 & 5

NOTES.—TABLE 63 B

1. Double riveted seams in association with $1\frac{1}{4}$ inch rivets may be fitted as an alternative to treble riveted seams and $1\frac{1}{8}$ inch rivets.

2. In seams of keel and sheerstrake the diameter of rivets and type of seam are to be regulated by the adjacent plating.

3. For number of rivets between transverse frames in seams of side plating *see* Table 63D. Where the form of the ship, forward and aft, is curved, or where longitudinal side framing is adopted, the spacing of the rivets is not to exceed $3\frac{1}{2}$ diameters where the thickness of plating does not exceed ·50 inch and 4 diameters where the thickness exceeds ·50 inch. Clear of cargo tanks the spacing of rivets in seams of sheerstrake, side and bottom plating is not to exceed $4\frac{1}{2}$ diameters. (For special requirements for ships above 500 feet, *see* note 4.)

4. In ships above 500 feet in length in the three seams nearest the neutral axis and for three-quarters of the length amidships the following additions are to be made:—

Above 500 feet and not exceeding 525 feet the spacing is not to exceed $3\frac{1}{2}$ diameters.

Above 525 feet and not exceeding 550 feet the seams are to be treble riveted and the spacing is not to exceed 4 diameters.

Above 550 feet the seams are to be treble riveted and the spacing is not to exceed $3\frac{1}{2}$ diameters.

5. In way of ice strengthening the diameter of the rivets used may be $\frac{1}{8}$ inch less than that required for the increased thickness of plating.

WELDING AND RIVETING

C

RIVETING OF SEAMS OF DECK PLATING

ITEM	THICKNESS		SEAMS			
	Above	Not exceeding	Diameter of rivets	Type	Breadth	Spacing of rivets centre to centre
	Inches	Inches	Inches		Inches	Inches
Strength deck stringer plate	*See* note 2					
Strength deck plating		·50	$\frac{3}{4}$	Double	$4\frac{1}{2}$	$2\frac{5}{8}$ ∧ 4
	·50	·72	$\frac{7}{8}$	Double	$5\frac{1}{4}$	$3\frac{1}{2}$ |
	·72	·94	1	Double	6	4 | *See* note
	·94	1·26	$1\frac{1}{8}$	Double	$6\frac{3}{4}$	$4\frac{1}{2}$ |
	1·26	1·50	$1\frac{1}{8}$	Treble	$9\frac{1}{2}$	$4\frac{1}{2}$ ∨
Sheerstrake stringer connection	*See* note 3					

NOTES.—TABLE 63 C

1. Double riveted seams in association with $1\frac{1}{4}$ inch rivets may be fitted as an alternative to treble riveted seams and $1\frac{1}{8}$ inch rivets.

2. In seams of stringer plates the diameter of rivets and number of rows are to be regulated by the thickness of adjacent deck plating.

3. The sheerstrake stringer connection is to be double riveted over the cargo tanks and for $\frac{1}{3}$ B into the poop. Where the length L exceeds 750 feet, or where the seams of the deck plating are to be treble riveted, the sheerstrake stringer connection is also to be treble riveted. The diameter of the rivets is to be governed by the thickness of the stringer bar and the rivets are to be spaced 5 diameters apart in each row. At the end of the ship the riveting is to be in accordance with Table 19.

4. The seams of strength deck plating at ends clear of oil tanks may be single riveted where the thickness of plating does not exceed ·72 inch and double riveted where the thickness exceeds ·72 inch. The rivets are to be spaced $4\frac{1}{2}$ diameters apart.

WELDING AND RIVETING

D

NUMBER OF RIVETS IN SEAMS OF SIDE SHELL PLATING BETWEEN TRANSVERSE FRAMES EXCLUDING RIVETS IN FRAMES

FRAME SPACING	THICKNESS OF SIDE SHELL IN INCHES		
	Not exceeding ·50	Above ·50 and not exceeding ·72	Above ·72 and not exceeding ·94
	DIAMETER OF RIVET IN INCHES		
	$\frac{3}{4}$	$\frac{7}{8}$	1
	NUMBER OF RIVETS IN EACH ROW		
Inches			
24	8	6	
24½	8	6	
25	9	6	
25½	9	7	
26	9	7	6
26½	9	7	6
27	9	7	6
27½	10	7	6
28	10	7	6
28½	10	7	6
29	10	8	7
29½	10	8	7
30	11	8	7
30½	11	8	7
31	11	8	7
31½	11	8	7
32	11	8	7
32½		8	8
33		9	8
33½		9	8
34		9	8
34½		9	8
35		9	8
35½		9	8
36		9	8

NOTES.—TABLE 63 D

1. For spacing of rivets clear of cargo tanks and where the form of the ship is curved *see* Table 63 B, Note 3.

2. For special requirements in ships above 500 feet in length *see* Table 63 B, Note 4.

WELDING AND RIVETING

E

CONNECTIONS OF LONGITUDINALS, FRAMES AND STIFFENERS TO PRIMARY SUPPORTING MEMBERS

1. The Area of Welds connecting longitudinals, frames and stiffeners to primary supporting members is not to be less than that given by the formula

$$A = \cdot 55 \sqrt{\frac{I}{y}} \text{ or 2 square inches, whichever is greater,}$$

where A = Area of weld in square inches as defined in 2 below,

$\frac{I}{y}$ = Section modulus of longitudinal, frame or stiffener in inches^3.

2. Area of weld is the product of the throat thickness and the total length of weld and includes both weld of web connection and weld of connection to stiffening bar. The throat thickness is not to be less than 80 per cent of that of the weld required by Table 63 A.

3. The area of weld required by 1 above is for bottom and side transverses; for deck transverses the area of weld is not to be less than half the value required by the formula.

4. Outside the tank space the area of weld may be 80 per cent of the value required by the formula and associated notes. The throat thickness of weld is not to be less than 67 per cent of that of the weld required by Table 63 A with a minimum of ·18 inch.

WELDING AND RIVETING

F

BRACKETS AT HEAD OF SIDE FRAMES AND AT ENDS OF VERTICAL STIFFENERS TO LONGITUDINAL AND TRANSVERSE BULKHEADS

1. The dimensions of brackets and their connections are not to be less than those given by the following formulæ:—

Length of Arm (l) $= 4{\cdot}5\sqrt{\frac{I}{y}} + 2$ inches.

Thickness $= {\cdot}03\sqrt{\frac{I}{y}} + {\cdot}25$ inch, or ·36 inch, whichever is greater but need not exceed ·50 inch.

Flange Width (see 4 below) $= {\cdot}5\sqrt{\frac{I}{y}} + {\cdot}50$ inch, or 4 inches whichever is less.

Weld Area (see 2 below) $= \frac{l}{6}$ square inches if $l \leqq 24$ inches.

,, $= \frac{l}{4} - 2$ square inches if $l > 24$ inches.

Dia. of Rivets $= \frac{3}{4}$ inch if $\frac{I}{y} \leqq 15$ inches^3.

,, $= \frac{7}{8}$ inch if $\frac{I}{y} > 15$ inches^3.

Number of Rivets $= 1{\cdot}4\sqrt{\frac{I}{y}} + {\cdot}5$ for $\frac{3}{4}$ inch rivets.

,, $= 1{\cdot}4\sqrt{\frac{I}{y}} - {\cdot}7$ for $\frac{7}{8}$ inch rivets.

Where $\frac{I}{y}$ = Section modulus of frame or stiffener.

2. Area of weld is the product of the throat thickness and the total length of weld, but the throat thickness is not to be less than 80 per cent of that of the weld required by Table 63 A.

3. Length of bracket arm is to be measured from the plating.

4. Flanges need not be fitted where the length of bracket arm is less than 18 inches.

5. For minimum thickness *see* D 5308.

TABLE 63 G

WELDING AND RIVETING

G

CONNECTION OF PRIMARY SUPPORTING MEMBERS TO FACE MATERIAL, SHELL, DECK AND BULKHEAD

FACE AREA (Square inches)		POSITION	WELDED		RIVETED		
			TO FACE MATERIAL	TO SHELL, DECK OR BULKHEAD	TO FACE MATERIAL	TO SHELL, DECK OR BULKHEAD	
			WELD FACTOR	WELD FACTOR	MAXIMUM SPACING OF RIVETS, CENTRE TO CENTRE IN DIAS.	NUMBER OF ROWS	MAXIMUM SPACING OF RIVETS, CENTRE TO CENTRE IN DIAS.
Above	Not exceeding						
	5·0	For a distance each end equal to ·2 × length	·33	·67	7	Double	5
		Remainder	·21	·33	7	Single	5
5·0	10·0	For a distance each end equal to ·2 × length	·50	·80	4	Double	5
		Remainder	·25	·60	6	Double	5
10·0	15·0	For a distance each end equal to ·2 × length	·80	1·00	5	Double with single riveted backbar	$4\frac{1}{2}$
		Remainder	·80*	·80	6	Double	$4\frac{1}{2}$
15·0	20·0	For a distance each end equal to ·2 × length	·80	1·00	4	Double with single riveted backbar	4
		Remainder	·80*	·80	5	Double	4
20·0	40·0	For a distance each end equal to ·2 × length	1·00	1·00			
		Remainder	·80	1·00			

* May be ·67 clear of oil cargo tanks

NOTES.—TABLE 63 G

1. Length for use in the above Table is the unsupported length of the member including end connections.

2. The extent of the increased connection at each end equal to ·2 × length given in the above Table is measured from the end of the member including the end bracket, but this length is to be extended as necessary beyond the toe of the bracket, and beyond the heel of the bracket to cover a contiguous member.

3. On vertical webs the increased welding or riveting may be omitted at the top, but at the bottom it is to extend for a distance equal to ·3 × length.

4. In ships over 400 feet long the weld factor of the connection of bottom transverses to the shell is not to be less than ·80 and that of the side transverses to shell, and the vertical webs to longitudinal and transverse bulkheads is not to be less than ·80 in the lower half; in riveted ships these connections are not to be less than double riveted angles.

5. Centre line deck and bottom girders are to be welded or riveted as given in the above Table.

6. For particulars of scalloped construction *see* D 5719 and notes under Table 63 A.

TABLE 63 H
(SEE CONTINUATION)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM			WELDED: WELD FACTOR	RIVETED: MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
FRAMES & LONGITUDINALS				
Side frames to shell	in cargo tanks, spacing not over 30 inches ...		·25	6
	in cargo tanks, spacing over 30 inches ...		·27	$5\frac{1}{2}$
	in deep, oil fuel and peak tanks		·27	$5\frac{1}{2}$
	in fore hold		·27	$5\frac{1}{2}$
	in machinery space, spacing not over 29 inches		·21	7
	in machinery space, spacing over 29 inches and up to 32 inches		·23	$6\frac{1}{2}$
	in machinery space, spacing over 32 inches and up to 34 inches		·25	6
	in machinery space, spacing over 34 inches ...		·27	$5\frac{1}{2}$
Tween deck frames and longitudinals to shell			·21	7
Web frames			*See* Table 63 G	
Bottom longitudinals to shell (except as below)	Where the length L does not exceed 400 ft.	For a distance either side of the bulkhead equal to ·25 × spacing of transverses	·80	4
		remainder (except in the forward ·25 L)	·25	6
	Where the length L does exceed 400 ft.	For a distance either side of the bulkhead equal to ·30 × spacing of transverses	·80	$3\frac{1}{2}$ with back angle
		remainder (except in the forward ·25 L)	·25	6
	In the forward ·25 L (except at ends of span, where as above)		·50	$4\frac{1}{2}$ with back angle
Bottom longitudinals of flatbar type to shell			Leg length 35 per cent of thickness of the thinner member being connected	
Side longitudinals to shell (*cont. next page*)	Not over 15 ft. below upper deck at side amidships		·25	6
	over 15 ft. and not over 25 ft. below upper deck at side amidships	For a distance either side of bulkhead equal to ·25 × spacing of transverses ...	·80*	$4\frac{1}{2}$
		remainder	·25	6

* May be ·67 clear of oil cargo tanks

For notes see page 217

TABLE 63 H
(SEE CONTINUATION)

WELDING AND RIVETING

H (*continued*)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM	WELDED — WELD FACTOR	RIVETED — MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
Side longitudinals to shell (*continued*) — Over 25 ft. below upper deck at side amidships — For a distance either side of bulkhead equal to ·25 × spacing of transverses	·80	$3\frac{1}{2}$
Side longitudinals to shell (*continued*) — Over 25 ft. below upper deck at side amidships — remainder	·25	6
Deck longitudinals to deck plating, except as below	·25	6
Deck longitudinals of flatbar type to deck plating	Leg length 35 per cent of thickness of the thinner member being connected	
Longitudinals to stiffening bars on primary supporting members ...	*See* Table 63 E	
Intercostal bottom side girders to shell	As for bottom longitudinals	
Intercostal deck side girders to deck plating	As for deck longitudinals	
Face bar of intercostal bottom and deck side girders to respective web plates	·30	7
Bottom frames to shell and floors forward	·50	$5\frac{1}{2}$—double riveted
Floors to centre girder or centre line bulkhead forward	1·00	4—double riveted
Floors and cross ties in fore peak	·25	6
Floors and cross ties in after peak	·30	5
PRIMARY SUPPORTING MEMBERS		
Bottom transverses to shell	*See* Table 63 G	
Side transverses to shell		
Deck transverses to deck plating		
Web frames to shell		
Vertical webs on longitudinal and transverse bulkheads ...		
Stringers to shell		
Horizontal girders to O.T. bulkheads		
Bottom transverses to longitudinal bulkheads and centre line girders	1·00	
Deck transverses to longitudinal bulkheads and centre line girders	·80	5—double riveted
BRACKETS		
End brackets of all primary supporting members	1·00	
Brackets at head of side frames	*See* Table 63 F	
Side frames to bilge brackets	To depend on arrangements adopted.	
End connections of longitudinals	Generally 1·00 but to depend on design.	
Brackets at ends of stiffeners on transverse bulkheads	To depend on end connections of longitudinals	
Tripping brackets	·25	6
Docking brackets	·30	5
Stiffening of primary supporting members *See also* Table 63 E ...	·21	7

For notes see page 217

H (*concluded*)

WELDING OR RIVETING OF VARIOUS STRUCTURAL CONNECTIONS

ITEM				WELDED	RIVETED
				WELD FACTOR	MAXIMUM SPACING OF RIVETS CENTRE TO CENTRE IN DIAMETERS
O.T. TRANSVERSE & LONGITUDINAL BULKHEADS					
Vertical stiffeners	spacing not exceeding 30 inches			·25	6
	spacing exceeding 30 inches			·27	$5\frac{1}{2}$
Horizontal stiffeners	Not over 15 ft. below highest point of tank ...			·25	6
	on longitudinal bulkheads	over 15ft. and not over 25ft.	For a distance either side of bulkhead equal to ·25 × spacing of transverses	·80	$4\frac{1}{2}$
			remainder	·25	6
		over 25 ft.	For a distance either side of bulkhead equal to ·25 × spacing of transverses	·80	$3\frac{1}{2}$
			remainder	·25	6
	on transverse bulkheads	Not over 18 ft. below highest point of tank		·25	6
		over 18 ft.		·30	5
Boundaries	of longitudinal bulkheads to bottom or deck ...			1·00 (continuous) *See* note 2.	5—double riveted
	of transverse bulkheads	to shell at bottom or bilge ...		1·00 (continuous)	5—double riveted
		to shell at sides or to deck ...		·80 (continuous)	5—double riveted
		to longitudinal bulkheads ...		·80 (continuous)	5—double riveted
Vertical webs ... ... Horizontal girders				*See* Table 63 G	

NOTES.—TABLE 63 H

1. Within the cargo tanks double continuous fillets having a leg length of less than ·80 of the Basic Leg Length (Table 63 A) are to be restricted to longitudinal framing and to bulkhead stiffening, and are to have a minimum leg length of ·18 inch or ·67 of the Basic Leg Length, whichever is greater.

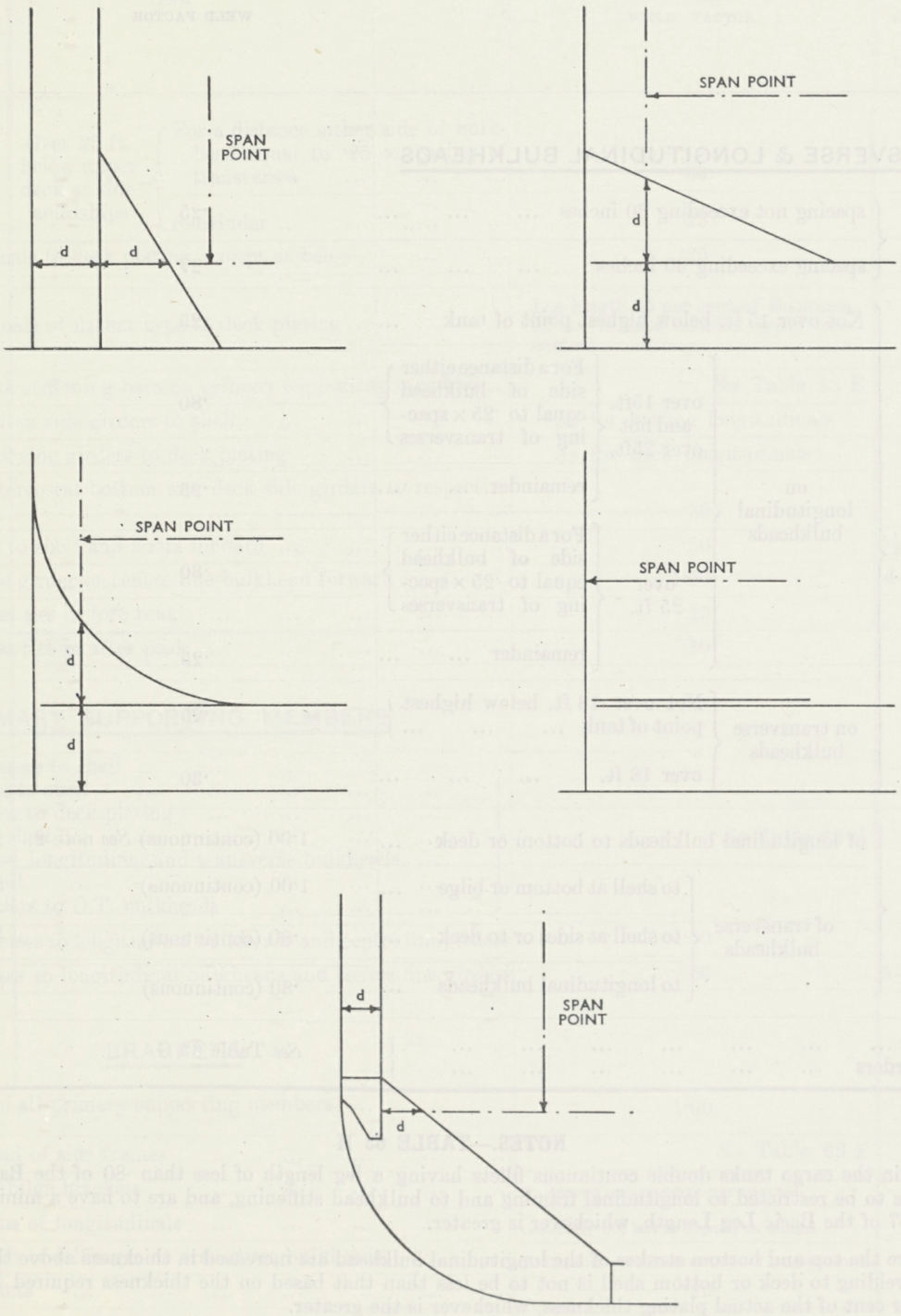
2. Where the top and bottom strakes of the longitudinal bulkhead are increased in thickness above the requirements of D 5006 the welding to deck or bottom shell is not to be less than that based on the thickness required by D 5006 or a leg length 35 per cent of the actual plating thickness, whichever is the greater.

3. The breadths of flanges of connecting angles are generally to be not less than four times the rivet diameter for rivets up to $\frac{7}{8}$ inch in diameter and three-and-a-half times for rivets 1 inch and above in diameter.

4. The distance from the centre of the rivet hole to the edge of the angle is to be not less than one-and-a-half rivet diameters.

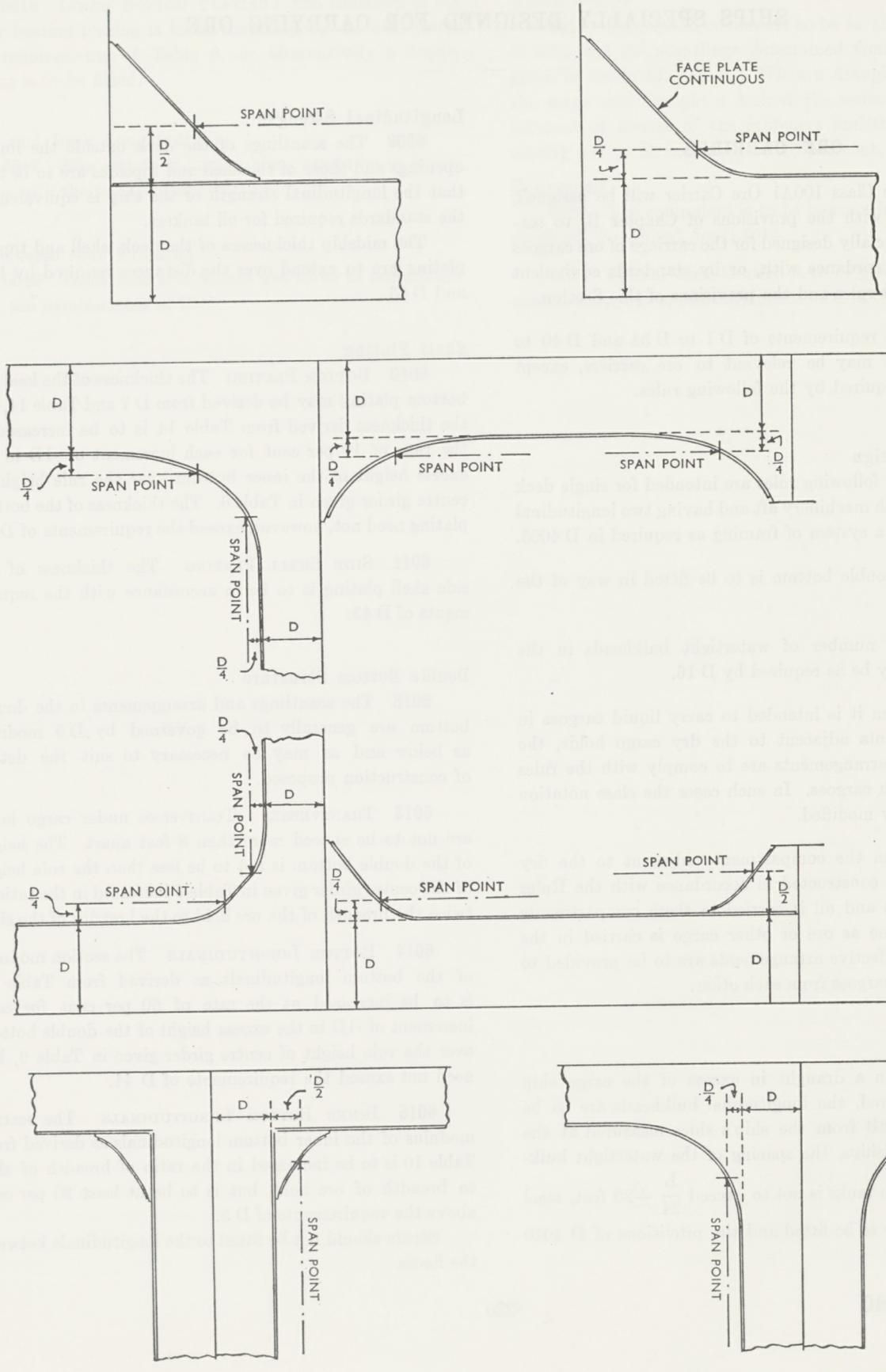
SPAN POINT

FOR LONGITUDINALS, FRAMES AND STIFFENERS



SPAN POINT

FOR PRIMARY SUPPORTING MEMBERS



SHIPS SPECIALLY DESIGNED FOR CARRYING ORE

Section 60

ORE CARRIERS

General

6001 The Class 100A1 Ore Carrier will be assigned, in accordance with the provisions of Chapter B, to sea-going ships specially designed for the carriage of ore cargoes and built in accordance with, or by standards equivalent to, the relevant rules and the provisions of this Section.

6002 The requirements of D 1 to D 34 and D 40 to D 57 apply as may be relevant to ore carriers, except as otherwise required by the following rules.

Structural Design

6003 The following rules are intended for single deck ore carriers, with machinery aft and having two longitudinal bulkheads and a system of framing as required in D 4003.

6004 A double bottom is to be fitted in way of the cargo holds.

6005 The number of watertight bulkheads in the cargo holds may be as required by D 16.

6006 When it is intended to carry liquid cargoes in the compartments adjacent to the dry cargo holds, the scantlings and arrangements are to comply with the rules relevant to such cargoes. In such cases the class notation may be suitably modified.

6007 When the compartments adjacent to the dry cargo holds are constructed in accordance with the Rules for Oil Tankers and oil is carried in these compartments at the same time as ore or other cargo is carried in the central holds, effective arrangements are to be provided to isolate the two cargoes from each other.

Draught

6008 When a draught in excess of the cargo ship draught is desired, the longitudinal bulkheads are to be not less than ·2B from the ship's sides measured at the draught d amidships, the spacing of the watertight bulkheads in the side tanks is not to exceed $\frac{L}{24}$ +20 feet, steel hatch covers are to be fitted and the provisions of D 4010 complied with.

Longitudinal Strength

6009 The scantlings of the deck outside the line of openings and those of the shell and topsides are to be such that the longitudinal strength of the ship is equivalent to the standards required for oil tankers.

The midship thicknesses of the deck, shell and topside plating are to extend over the distances required by D 42 and D 43.

Shell Plating

6010 Bottom Plating The thickness of the keel and bottom plating may be derived from D 7 and Table 14, but the thickness derived from Table 14 is to be increased at the rate of 10 per cent for each increment of ·1D in the excess height of the inner bottom over the rule height of centre girder given in Table 6. The thickness of the bottom plating need not, however, exceed the requirements of D 43.

6011 Side Shell Plating The thickness of the side shell plating is to be in accordance with the requirements of D 43.

Double Bottom Structure

6012 The scantlings and arrangements in the double bottom are generally to be governed by D 5 modified as below and as may be necessary to suit the details of construction proposed.

6013 Transverses Transverses under cargo holds are not to be spaced more than 8 feet apart. The height of the double bottom is not to be less than the rule height of the centre girder given in Table 6 increased in the ratio of twice the breadth of the ore hold to the breadth of the ship.

6014 Bottom Longitudinals The section modulus of the bottom longitudinals as derived from Table 10 is to be increased at the rate of 50 per cent for each increment of ·1D in the excess height of the double bottom over the rule height of centre girder given in Table 6, but need not exceed the requirements of D 44.

6015 Inner Bottom Longitudinals The section modulus of the inner bottom longitudinals as derived from Table 10 is to be increased in the ratio of breadth of ship to breadth of ore hold, but is to be at least 20 per cent above the requirements of D 5.

Struts should not be fitted to the longitudinals between the floors.

6016 Inner Bottom Plating The thickness of the inner bottom plating is to be increased by ·20 inch above the requirements of Table 6, or alternatively a double ceiling is to be fitted.

Side and Deck Longitudinals

6017 Side and deck longitudinals are to be in accordance with the requirements of D 44.

Transverse Side Framing

6018 Transverse side frames are to be in accordance with the requirements of D 45.

14th June, 1956

Hatch Covers

6019 Steel hatch covers are to be in accordance with D 2325 and the scantlings determined from the formulæ given in Table 43, note 6. When a draught in excess of the cargo ship draught is desired, the section modulus and moment of inertia of the stiffeners and thickness of the plating are to be increased by 15 per cent.

Equipment

6020 The equipment is to be in accordance with D 33 modified, if required, by D 4014.

6021 Special consideration is to be given to details of construction not specifically mentioned in the above rules.

Chapter D

PROVISIONAL REQUIREMENTS FOR THE CARRIAGE OF LIQUEFIED PETROLEUM AND NATURAL GASES AT OR NEAR ATMOSPHERIC PRESSURE

Section 70

General

7001 The class "100A1 Liquefied Gas Carrier, minimum temperature (to be specified)" will be assigned to ships specially designed for the carriage of liquefied petroleum or natural gases in separate tanks at low temperatures at or near atmospheric pressure and built in accordance with, or equivalent to, the relevant sections of the Rules and the following special requirements.

These requirements are based on the assumption that the insulation is fitted on the hull structure. Where the cargo tank itself is insulated, equivalent arrangements are to be provided.

Ship's Structure

7002 Vessels are to be designed with a double bottom and two longitudinal bulkheads forming side tanks.

7003 Transverse bulkheads within the range of cargo tanks are to be arranged as floodable cofferdams, except where the cargo is to be carried at a temperature not lower than —60° F. In this case single transverse bulkheads may be accepted, provided they are constructed of Grade E steel and are sufficiently insulated on both sides.

7004 Cofferdams are to be arranged at each end of the tank space.

7005 Ship's structural members adjacent to the gas cargo tanks may be constructed of ordinary mild steel as required by Chapter D of the Rules, provided:—

(i) The arrangements are such that the temperature of the steel will not be less than 30° F. when the cargo tanks are at the service temperature, and the air temperature is 40° F.

(ii) A secondary barrier is provided which will act as a temporary containment for the liquefied gas in the event of leakage from the containers.

(iii) Thermo-couples are provided on the ship's structure adjacent to the gas tanks and the arrangements are such as to give continuous temperature readings and audible warnings of the development of a cold spot.

7006 Arrangements are to be provided to enable the double bottom, wing tank spaces and all transverse cofferdams to be flooded in the event of leakage from the cargo tanks.

7007 A monitoring system is to be installed to ensure that any leakage from the tanks is immediately detected and the space between the cargo tanks and surrounding structure is to be permanently filled with an inert gas.

7008 Where the liquefied gas is to be carried at a temperature not below —60° F. and it is proposed to use steel of specially high notch toughness (Grade E) in the hull construction, special consideration will be given to the above requirements.

Cargo Tanks

7009 The material to be used in the construction of the cargo tanks must have suitable mechanical properties at the service temperature. Particulars of the material proposed are to be submitted for approval.

7010 Where a ferritic steel is to be used, tensile, bend and Charpy V-notch impact test pieces are to be prepared from each plate or section. The dimensions of the test pieces are to be in accordance with the requirements contained in P 203, P 204, P 206 and P 207.

The results of the tensile and bend tests are to comply with the approved specification. For the Charpy V-notch impact tests the "required temperature" is the lowest service temperature and the results of the tests are to give an average energy for fracture of not less than 40 ft. lbs.

Other criteria and methods of testing will be accepted where considered equivalent to the above requirements.

7011 It is to be demonstrated by procedure tests that the proposed methods of welding are satisfactory and produce sound welds. Charpy V-notch impact test pieces are to be prepared from butt welded test plates and are to be notched in the heat affected zone and, if the deposited metal is a ferritic steel, further test pieces are to be notched in the weld. Unless otherwise approved, the results of the impact tests on these test pieces at the minimum temperature of service are not to be less than those specified for the parent material.

7012 For materials other than ferritic steels, the proposed material specification is to be submitted. The notched properties as determined by suitable tests and/or evidence of comparable service experience, at temperatures lower than or equal to the minimum service temperature are also to be submitted, together with corresponding data on the weld metal and heat affected zone.

7013 The tanks shall be designed to withstand:—

(i) A test head of 8 feet of water above the top of the tank or 2 feet above the top of the hatch, whichever may be the greater.

(ii) The combined effect of internal vapour pressure (if any), and rolling, pitching and heaving as follows:—

(1) A complete 30° roll port and starboard (i.e., through 120°) in a period of ten seconds.

(2) A pitch of 6° half amplitude in a pitch period of seven seconds (i.e., through 24° in seven seconds).

(3) A heave of L/80 feet half amplitude in a period of eight seconds (i.e., through L/20 feet in eight seconds).

With the loading determined in accordance with the above, the stress in any item shall not exceed three-quarters of the yield stress or three-eighths of the ultimate stress.

7014 Means are to be provided to prevent excessive pressure coming on to the tanks. (*See* 7029.)

7015 The tanks are to be supported on substantial foundations arranged to avoid excessive concentration of load on the ship's structure or on the tank. Provision is to be made for the thermal contraction of the tanks on cooling from ambient to service temperature and arrangements are to be made to control the movement of the tanks when the vessel is rolling and pitching.

7016 The arrangement of tanks and insulation is to be such that at least one side of the tank plating and adjacent hull structure is readily accessible for inspection (except as qualified in 7003).

7017 During the construction of the tanks all butt welds are to be radiographed.

7018 The tanks are to be tested on completion with a head of water in accordance with 7013 (i).

7019 Thermo-couples are to be fitted to at least one tank to enable a satisfactory pre-cooling procedure to be established unless other satisfactory arrangements can be made.

Insulation

7020 The insulation is to be of an approved type and of sufficient thickness to comply with paragraph 7005 (i) of these requirements. It is to be suitable for the loads imposed and adequately protected against penetration of vapour.

Particulars of the insulating material(s) and the estimated heat conductivity value(s) at the service conditions are to be supplied, together with the proposed thickness(es) and methods of fitting, jointing and sealing the insulation.

Annual and Special Surveys

7021 The inner surfaces of the cargo tanks are to be examined annually.

7022 At special surveys special consideration will be given to the necessity for removing insulation from the hull structure but, in general, provided the Surveyor is satisfied that it is adhering satisfactorily and there are no traces of cold spots, this will not be required until the vessel is at least eight years old.

Valves, Fittings and Piping

7023 All materials used in the piping systems must be suitable for the proposed service. Full particulars of the materials including chemical composition and mechanical properties at the service temperature are to be submitted for consideration.

7024 Joints may be of butt-welded or flanged type. Couplings of approved type may be used for joints $1\frac{1}{2}$ inches diameter or smaller.

7025 Provision is to be made, where necessary, for expansion and contraction in the pipe lines.

7026 All piping is to be suitably secured. Low temperature pipes are to be adequately insulated and provided with temperature isolation from the hull. Drip trays are to be fitted to protect the hull in places where cargo leakage or spillage is likely to occur.

7027 Piping should preferably enter the cargo tanks above the weather deck. Piping may, however, be below the weather deck, provided it is situated in a compartment which is suitable for temporary containment of the liquefied gas, as defined in 7005 (ii), in the event of leakage from the pipes.

7028 Provision is to be made for the prompt removal of any liquefied gas which may leak from the cargo tanks or piping into the temporary containment spaces.

7029 Each cargo tank is to be protected by one or more pressure-vacuum relief valves discharging into a vapour main led up the mast or other post to a safe height above the weather deck. The pressure relief valves should be of sufficient capacity:—

(i) To discharge the vapours formed by heat leakage into the cargo tanks at ambient temperatures of up to 115° F. plus the vapour displaced by the maximum rate of loading.

(ii) To discharge the vapours formed by exposure of the cargo tank walls to fire.

The total capacity and pressure setting of these valves would have to be specially considered for each installation, but in no case should the pressure relief valves be less than 4 inches diameter.

7030 Sections of piping which may be isolated shall be provided with relief valves discharging to the main vapour line.

7031 Shut-off valves or cocks shall be provided at the connections to each cargo tank except connections to safety relief and liquid level gauging devices. Liquid level gauging devices are to be adequately protected against damage.

26th January, 1961

7032 Suitable provision is to be made for pre-cooling the cargo tanks before loading is commenced.

7033 A liquid level gauging device and a high level alarm device shall be provided for each cargo tank.

7034 All cargo pumps shall be capable of being stopped from a position outside the range of the cargo tanks.

Refrigerating Plant

7035 Where refrigerating plant is to be installed for dealing with the cargo on board, particulars of the plant and appliances will be required.

Electrical

7036 Thermo-couples and their circuits fitted in accordance with 7005 (iii) and 7019 are to be

(i) certified intrinsically safe

or

(ii) of such construction and design that a reasonably equivalent degree of safety is assured.

7037 In other respects the electrical installation is to comply with M 16 (Special requirements for oil tankers and ships intended for the carriage in bulk of liquid cargoes having a flash point of 150° F. (65.5° C.) or less).

Chapter E

PUMPING AND PIPING

101 The following plans are to be submitted for consideration:—

General pumping arrangements, including air and sounding pipes and any cross flooding pipes and fittings. (Shipbuilder's plan.)

Pumping arrangements at the forward and after ends of oil tankers and drainage of cofferdams and pump rooms.

General arrangement of cargo piping in tanks and on deck of oil tankers.

Piping arrangements for cargo oil (F.P. above 150° F.).

Bilge, ballast and oil fuel pumping arrangements in the machinery space, including the capacities of the pumps on bilge service. In the case of passenger ships the criterion numeral, as defined in the International Convention for the Safety of Life at Sea–1948 is to be stated together with the number of flooded compartments which the ship is required to withstand under damage conditions.

Arrangement of oil fuel pipes and fittings at settling and service tanks.

Arrangement of oil fuel piping in connection with oil burning installations and oil fired galleys.

Oil fuel and cargo oil overflow systems, where these are fitted.

Arrangement of boiler feed system.

Oil fuel settling, service and other oil fuel tanks not forming part of the ship's structure.

Above plans of machinery space piping are to be diagrammatic.

Arrangement and dimensions of main steam pipes with details of flanges, bolts and weld attachments and particulars of the material of pipes, flanges, bolts and electrodes.

NOTE.—Plans additional to the above should not be submitted unless the arrangements are of a novel or special character affecting classification.

Section 2

GENERAL

201 In power driven ships the pumping arrangements according to the division of compartments, rise of floor and other conditions are to be as detailed in these Rules which apply to passenger ships, cargo and other ships except where otherwise stated.

202 While the arrangements satisfy the requirements of the International Convention for the Safety of Life at Sea–1948, attention should be given to any relevant statutory requirements of the National Authority of the country in which the ship is to be registered.

203 The Committee will be prepared to give consideration to special cases or to arrangements which are fully equivalent to those required by these Rules. Consideration will also be given to the pumping arrangements of small ships and ships to be assigned class notations for restricted or special services.

(For pumping arrangements of non-propelled ships, *see* E 10.)

BILGE AND BALLAST

204 All ships are to be provided with efficient pumping plant having the suctions and means for drainage so arranged that any water within any compartment of the ship, or any watertight section of any compartment, can be pumped out through at least one suction when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. For this purpose wing suctions will generally be necessary, except in short, narrow compartments where one suction can provide effective drainage under the above conditions.

In passenger ships the pumping plant is to be capable of draining any watertight compartment under all practical conditions after a casualty, whether the ship is upright or listed.

Hold Drainage

205 In ships having only one hold, and this over 110 feet in length, bilge suctions are to be fitted in suitable positions in the after half-length, also in the forward half-length of the hold.

206 Where close ceiling or continuous gusset plates are fitted over the bilges, arrangements are to be made whereby water in a hold compartment may find its way to the suction pipes.

207 Where the inner bottom plating extends to the ship's side, the bilge suctions are to be led to wells placed at the wings. If the tank top plating has inverse camber, a well is also to be fitted at the centre line.

Bilge wells are to be formed of steel plates and are to be of not less than 6 cubic feet capacity. In small compartments, steel bilge hats of reasonable capacity may be fitted.

In passenger ships wells in double bottom tanks are not to extend downwards more than necessary; the depth of the well is in no case to be more than the depth less 18 inches of the double bottom at the centre line, nor shall the well extend below the horizontal plane referred to in D 526.

Where access manholes to bilge wells are necessary, they are to be fitted as near to the suction strums as practicable.

208 Access to the bilge suction strum of a hold well should not be obtained by means of a manhole in the machinery space watertight bulkheads or tank top plating in the machinery space or tunnel if this can be avoided.

Where, however, this arrangement is necessary, the watertight manhole cover should be of hinged type and an instruction plate, in raised letters, should be affixed in a well lighted position, to the effect that this door must be kept shut, except when access is required. In passenger ships these arrangements are not permissible.

209 The intactness of the machinery space bulkheads, and of tunnel plating which is required to be of watertight construction, is not to be impaired by the fitting of scuppers discharging to machinery space or tunnels from adjacent compartments which are situated below the bulkhead deck.

These scuppers may, however, be led into a strongly constructed scupper drain tank situated in the machinery space or tunnel but closed to these spaces and drained by means of a suction of appropriate size led from the main bilge line through a screw-down non-return valve.

The tank air pipe is to be led to above the bulkhead deck and provision is to be made for ascertaining the level of water in the tank.

Where one tank is used for the drainage of several watertight compartments, the scupper pipes are to be provided with screw-down non-return valves.

210 Steering gear compartments or other small enclosed spaces situated above the after peak tank are to be provided with suitable means of drainage either by hand or power pump bilge suctions.

If, however, these compartments are adequately isolated from the adjacent 'tween decks, they may be drained by scuppers not less than $1\frac{1}{2}$ inches bore, discharging to the tunnel and fitted with self-closing cocks situated in well lighted and visible positions. These arrangements are not applicable to passenger ships unless specially approved in relation to sub-division considerations.

Drainage from Refrigerated Cargo Spaces

211 Provision is to be made for the continuous drainage of the inside of all insulated chambers and cooler trays.

212 Drains which are led from lower holds and cooler trays situated on the tank top are to be fitted with liquid sealed non-return bilge traps.

Drains from 'tween deck chambers and from cooler trays which are situated well above the tank top are also to be fitted with liquid sealed traps, but the non-return valves may be omitted if desired. (For insulation of scupper pipes, *see* E 418.)

213 Where drains from separate chambers join a common main, the branch pipes are each to be provided with a liquid sealed trap.

214 The liquid sealed traps are to be of adequate depth and arrangements are to be made for ready access to the traps for cleaning and refilling with brine.

215 Sluices, scuppers or drain pipes which would permit drainage from compartments outside the insulated chambers into the bilges of the latter are not to be fitted.

216 Screwed plugs or other means for blanking off scuppers draining insulating chambers and cooler trays are not to be fitted.

If, however, it is specially desired by the Owners to provide means for temporarily closing these scuppers, they may be fitted with shut-off valves controlled from readily accessible positions on a deck above the load water line.

Machinery Space—Bilge Drainage

217 The bilge drainage arrangements in the machinery space are to be such that any water which may enter this compartment can be pumped out through at least two bilge suctions when the ship is on an even keel and is either upright or has a list of not more than 5 degrees. One of these suctions is to be a branch bilge suction, i.e., a suction connected to the

main bilge line, and the other is to be led direct from an independent power pump. Examples of the necessary arrangements are detailed in 218 to 220.

In passenger ships the drainage arrangements are to be such that machinery spaces can be pumped out under all practical conditions after a casualty whether the ship is upright or listed.

218 Where the double bottom extends the full length of the machinery space and forms bilges at the wings, it will be necessary to provide one branch and one direct bilge suction at each side.

219 Where the double bottom plating extends the full length and breadth of the compartment, one branch bilge suction and one direct bilge suction are to be led to each of two bilge wells of not less than 6 cubic feet capacity, situated one at each side.

In passenger ships the depth of bilge wells is to comply with the requirements of 207.

220 Where there is no double bottom and the rise of floor is not less than 5 degrees, one branch and one direct bilge suction are to be led to accessible positions as near the centre line as practicable.

In ships where the rise of floor is less than 5 degrees and in all passenger ships additional bilge suctions are to be provided at the wings.

221 Additional bilge suctions may be required for the drainage of depressions in the tank top formed by crank pits, or other recesses, by tank tops having inverse camber or by discontinuity of the double bottom.

222 In ships in which the propelling machinery is situated at the after end of the ship, it will generally be necessary for bilge suctions to be fitted in the forward wings as well as the after end of the machinery space, but each case will be dealt with according to the size and structural arrangements of the compartment.

223 In ships propelled by electrical machinery, special means are to be provided to prevent the accumulation of bilge water under the main propulsion generators and motors.

224 Where the machinery space is divided by watertight bulkheads to separate the boiler room(s) or auxiliary engine room(s) from the main engine room, the number and position of the branch bilge suctions in the boiler room(s) and auxiliary engine room(s) are to be the same as for cargo holds.

In addition to the branch bilge suctions an independent power pump direct bilge suction, is to be fitted in each compartment. Similar provision is to be made in separate motor rooms of electrically propelled ships.

225 In passenger ships each independent bilge pump is to have a direct bilge suction from the space in which it is situated, but not more than two such suctions are required in any one space. Where two or more such suctions are provided there is to be at least one suction on each side of the space.

Machinery Space—Emergency Bilge Drainage

226 In steamers, the main circulating water pump to each main engine is to be fitted with an emergency bilge suction, i.e., "bilge injection", which is to be additional to the bilge suctions detailed in 217 to 225. This suction, which is to have a diameter of at least two-thirds that of the pump suction, is to be led to a suitable low level in the machinery space and is to be fitted with a screw-down non-return valve having the spindle so extended that the handwheel is not less than 18 inches above the bottom platform.

If two pumps are provided for one engine, each capable of supplying sufficient cooling water for normal power, only one pump need be fitted with an emergency bilge suction.

In coal-burning steamships a flexible bilge hose is to be provided for connecting to the independent power bilge pump. The hose is to have an internal diameter of 4 inches or that required for the main bilge line, whichever is the less, and is to be of sufficient length to reach any part of the engine and boiler room bilges into which coal or ashes could be washed. The lower end of the hose is to be provided with a strainer.

The hose fitting on the pump is to comply with the requirements of 246.

227 In motorships, the emergency bilge suction is to be led to the main cooling water pump or to the main cooling water suction line. The suction is to be of the same size as the suction branch of the cooling water pump and the valve nameplate is to be marked "For emergency use only".

Alternatively, the emergency bilge suction may be led to the largest available power pump which is not fitted with a direct bilge suction and is to be of the same size as the suction branch of the pump. This pump is to have a capacity greater than that required for a bilge pump, and if it is of the self-priming type the direct bilge suction on the same side of the ship as the emergency suction may be omitted, except in passenger ships.

Tunnel Drainage

228 The tunnel well is to be drained by a suction from the main bilge line. In all ships including passenger ships this well may extend to the outer bottom.

229 Where the tank top in the tunnel slopes down from aft to forward, a bilge suction is to be provided at the forward end of the tunnel, in addition to the tunnel well suction required by 228.

Sizes of Bilge Suction Pipes

230 The diameters of bilge suction pipes are to be not less than required by the following formulæ, to the nearest quarter inch:—

Main Bilge Line

$$d_m = \sqrt{\frac{L(B + D)}{2500}} + 1 \qquad (a)$$

In no case is the diameter of the main bilge line to be less than required for any branch bilge suction.

Branch Bilge Suctions to Cargo and Machinery Spaces

$$d_b = \sqrt{\frac{C(B + D)}{1500}} + 1 \qquad (b)$$

where d_m = internal diameter of main bilge line, in inches,

d_b = internal diameter of branch bilge suction, in inches,

L = Rule length of ship, in feet,

B = Rule breadth of ship, in feet,

D = moulded depth to bulkhead deck, in feet,

C = length of compartment, in feet.

No bilge suction pipe is, however, to be less than 2 inches bore.

Direct Bilge Suctions, other than Emergency Suctions

231 The direct bilge suctions in the main engine room and the direct bilge suctions in large separate boiler rooms, motor rooms of electrically propelled ships and auxiliary engine rooms are to be of a diameter not less than required for the main bilge line.

Where the separate machinery spaces are of small dimensions, the sizes of the direct bilge suctions to these spaces will be specially considered.

For sizes of emergency bilge suctions, *see* 226 and 227.

232 In oil tankers and similar ships where the engine room pumps do not deal with bilge drainage outside the machinery space, the diameter of the main bilge line may be less than required by 230, formula (*a*) provided the cross-sectional area is not less than twice that required for the branch bilge suctions in the machinery space.

233 The area of each branch pipe connecting the bilge main to a bilge distribution chest is to be not less than the sum of the areas required by the Rules for the two largest branch bilge suction pipes connected to that chest, but need not be greater than that required for the main bilge line.

234 The bilge suction pipe to the tunnel well is to be not less than $2\frac{1}{2}$ inches bore, except in ships not exceeding 200 feet in length, in which case it may be 2 inches bore.

Bilge and General Service Pumps

235 For ships other than passenger ships at least two power bilge pumping units are to be provided in the machinery space. In ships of 300 feet in length and under, one of these units may be worked from the main engines and the other is to be independently driven. In larger ships both units are to be independently driven.

Each of these units is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of bilge line of not less than 400 feet per minute under ordinary working conditions, but where one unit is of slightly less than this capacity, the deficiency may be made good by an excess capacity of the other unit.

236 Table of Capacities

Bore of bilge pipe in inches	Capacity of each pumping unit in tons/hr.	Bore of bilge pipe in inches	Capacity of each pumping unit in tons/hr.
2	15	$5\frac{1}{4}$	103
$2\frac{1}{4}$	19	$5\frac{1}{2}$	113
$2\frac{1}{2}$	23	$5\frac{3}{4}$	124
$2\frac{3}{4}$	28	6	135
3	34	$6\frac{1}{4}$	146
$3\frac{1}{4}$	40	$6\frac{1}{2}$	158
$3\frac{1}{2}$	46	$6\frac{3}{4}$	171
$3\frac{3}{4}$	53	7	183
4	60	$7\frac{1}{4}$	197
$4\frac{1}{4}$	68	$7\frac{1}{2}$	210
$4\frac{1}{2}$	76	$7\frac{3}{4}$	224
$4\frac{3}{4}$	84	8	239
5	93	$8\frac{1}{4}$	254

237 Each unit may consist of one or more pumps connected to the main bilge line, provided their combined capacity is adequate.

238 In ships other than passenger ships a bilge ejector in combination with a high pressure sea water pump may be accepted as a substitute for an independent bilge pump required by 235.

239 For passenger ships at least three power bilge pumps are to be provided, one of which may be operated from the main engines. Where the criterion numeral is 30 or more, one additional independent power pump is to be provided. A main engine driven pump may be replaced by an independent pump. Each pump is to be connected to the main bilge line and is to be capable of giving a speed of water through the Rule size of main bilge pipe of not less than 400 feet per minute.

For location of pumps, *see* 256.

Self-Priming Pumps

240 All power pumps which are essential for bilge services are to be of self-priming type, unless an approved central priming system is provided for these pumps. Details of this system are to be submitted.

Cooling water pumps having bilge ejection connections need not be of self-priming type.

Pump Connections

241 The connections at the bilge pumps are to be such that one unit may continue in operation when the other unit is being opened up for overhaul.

242 Pumps required for essential services are not to be connected to a common suction or discharge chest or pipe unless the arrangements are such that the working of any of the pumps so connected is unaffected by the other pumps being in operation at the same time.

Direct Bilge Suctions

243 The direct bilge suctions in the machinery space(s) are to be led to independent power pump(s), and the arrangements are to be such that these direct suctions can be used independently of the main bilge line suctions.

Main Bilge Line Suctions

244 Suctions from the main bilge line, i.e., branch bilge suctions, are to be arranged to draw water from any hold or machinery compartment of the ship, excepting small spaces such as those mentioned in 262, where manual pump suctions are accepted, and are to be of not less size than required by 230, formula (*b*). (For special arrangements for oil tankers, *see* E1112 to E1117.)

Pipe Systems and their Fittings

245 The arrangement of valves, cocks and their connections is to be such as to prevent the possibility of one watertight compartment being placed in communication with another, or of dry cargo spaces, machinery spaces or other dry compartments being placed in communication with the sea or with tanks.

To effect this requirement, the bilge connections to any pump having also suctions from the sea and from tanks should be made either by means of non-return valves or cocks which cannot permit communication between the bilges and the sea or compartments in use as tanks.

246 Screw-down non-return valves are to be provided in the following fittings:—

Bilge valve distribution chests;

Bilge suction hose connections, whether fitted direct to the pump or on the main bilge line;

Direct bilge suctions and bilge pump connections to main bilge line.

247 Bilge pipes which are required for draining cargo or machinery spaces are to be entirely distinct from sea inlet pipes or from pipes which may be used for filling or emptying spaces where water or oil is carried. This does not, however, exclude a bilge ejection connection, a connecting pipe from a pump to its suction valve chest, or a deep tank suction pipe suitably connected through a change-over device to either a bilge, ballast or oil line.

248 Suctions for bilge drainage in machinery spaces and tunnels, other than emergency suctions, are to be led from easily accessible mud boxes fitted with straight tail pipes to the bilges and having covers secured in such a manner as to permit of their being expeditiously opened or closed. Strum boxes are not to be fitted to the lower ends of these tail pipes.

249 The open ends of bilge suctions in holds and other compartments outside machinery spaces and tunnels, are to be enclosed in strum boxes having perforations not more than $\frac{3}{8}$ inch diameter, whose combined area is not less than twice that required for the suction pipe. The boxes are to be so constructed that they can be cleared without breaking any joint of the suction pipe.

The distance between the foot of all bilge tail pipes and the bottom of the bilge or well is to be adequate to allow a full flow of water and to facilitate cleaning.

250 All cocks and valves in connection with bilge, ballast and fresh water suction pipes are to be fitted with legible nameplates and, unless otherwise specifically mentioned in the Rules, are to be fitted in places where they are at all times readily accessible.

251 Bilge cocks, valves and mud boxes are to be fitted at, or above, the machinery space and tunnel platforms.

Where it is not practicable to avoid the fittings being situated at the starting platform or in passageways, they may be situated just below the platform, provided readily removable traps or covers are fitted and nameplates indicate the presence of these fittings.

If relief valves are fitted to pumps having sea connections, these valves are to be fitted in readily visible positions above the platform.

252 Bilge suction pipes are not to be carried through double bottom tanks if it is possible to avoid doing so.

Bilge pipes which pass through these tanks are to be of substantial strength and are to be tested, after fitting, to the same pressure as the tanks through which they pass.

253 In way of deep tanks for water ballast, fresh water, oil fuel or cargo oil, bilge pipes should preferably be led through pipe tunnels but, where this is not done, the pipes are to be of steel of heavy gauge with welded joints or heavy flanged joints. The number of joints is to be kept to a minimum.

Expansion bends, not glands, are to be fitted to these pipes within the tanks, and the open ends of the bilge suction pipes in the holds are to be fitted with non-return valves of the special type approved for use in holds (*see* 266.)

Tank piping, other than that of the deep cargo tank pumping system, is not to be situated within deep cargo oil tanks.

The pipes are to be tested, after fitting, to a pressure not less than the maximum head to which the tanks can be subjected.

254 Bilge, ballast and cooling water suction and discharge pipes are to be permanent pipes made in readily removable lengths with flanged joints, except as mentioned in 253, and are to be efficiently secured in position to prevent chafing or lateral movement.

Long or heavy lengths of pipes are to be supported by bearers so that no undue load is carried by the flanged connections of the pumps or fittings to which they are attached.

Where lack of space prevents the use of normal circular flanges, details of the alternative methods of joining the pipes are to be submitted.

Pipes for the bilge and ballast systems are to be made of cast or wrought iron, steel, copper or other approved material. Heat sensitive materials such as lead are not to be used.

255 Suitable provision for expansion is to be made in each range of pipes.

Bilge Drainage and Cross Flooding Arrangements for Passenger Ships in Damaged Condition

256 In passenger ships the power bilge pumps are, if practicable, to be placed in separate watertight compartments which will not readily be flooded by the same damage. If the engines and boilers are in two or more watertight compartments, the bilge pumps are to be distributed throughout these compartments as far as possible.

In passenger ships of 300 feet or more in length or having a criterion numeral of 30 or more, the arrangements are to be such that at least one power pump will be available for use in all ordinary circumstances in which the ship may be flooded at sea. This requirement will be satisfied if:—

(*a*) One of the pumps is an emergency pump of a submersible type having a source of power situated above the bulkhead deck or,

(*b*) The pumps and their sources of power are so disposed throughout the length of the ship that, under any conditions of flooding which the ship is required by statutory regulation to withstand, at least one pump in an undamaged compartment will be available.

257 The bilge main is to be arranged so that no part is situated nearer the side of the ship than $\frac{B}{5}$ where B is the breadth of the ship.

Where any bilge pump or its pipe connection to the bilge main is situated outboard of the $\frac{B}{5}$ line then a non-return valve is to be provided in the pipe connection at the junction with the bilge main. The emergency bilge pump and its connections to the bilge main are to be arranged so that they are situated inboard of the $\frac{B}{5}$ line.

258 Provision is to be made to prevent the compartment served by any bilge suction pipe being flooded in the event of the pipe being severed, or otherwise damaged by collision or grounding in any other compartment. For this purpose, where the pipe is at any part situated nearer the side of the ship than $\frac{B}{5}$ or in a duct keel, a non-return valve is to be fitted to the pipe in the compartment containing the open end.

259 All the distribution boxes, cocks and valves in connection with the bilge pumping arrangements are to be so arranged that, in the event of flooding, one of the bilge pumps may be operative on any compartment. If there is only one system of pipes common to all pumps, the necessary cocks or valves for controlling the bilge suctions must be capable of being operated from above the bulkhead deck. Where in addition to the main bilge pumping system an emergency bilge pumping system is provided, it is to be independent of the main system and so arranged that a pump is capable of operating on any compartment under flooding conditions; in this case only the cocks and valves necessary for the operation of the emergency system need be capable of being operated from above the bulkhead deck.

260 All cocks and valves mentioned in the foregoing paragraphs which can be operated from above the bulkhead deck are to have their controls at their place of operation clearly marked and provided with means to indicate whether they are open or closed.

261 Where divided deep tanks or side tanks are provided with cross flooding arrangements to limit the angle of heel after side damage, the arrangements are either to be self acting or controlled from above the bulkhead deck.

Fore and After Peak Drainage

262 Where the peaks are used as tanks, a separate power pump suction is to be led to each tank, except in the case of small tanks used for the carriage of domestic fresh water, when hand pumps may be used.

Where the peaks are not used as tanks and main bilge line suctions are not fitted, drainage of both peaks may be effected by hand pump suctions, provided the suction lift be well within the capacity of the pumps and in no case exceeds 24 feet.

Provision is to be made for the drainage of the chain locker and the watertight flat above the fore peak tank by hand or power pump suction. (For drainage of the flat above the after peak tank, *see* 210.)

Where a suction pipe is led from the engine room to the fore peak, either through a hold space or through a tank intended to carry oil fuel, it is to be provided with a screw-down valve capable of being operated from an accessible position above the bulkhead deck, the chest being secured to the collision bulkhead inside the fore peak. An indicator is to be provided to show whether the valve is open or shut.

Watertight Bulkhead and Tunnel Fittings

263 No drain valve or cock is to be fitted to the collision bulkhead.

Drain valves or cocks are not to be fitted to other watertight bulkheads, if alternative means of drainage are practicable.

Where fitted, the valves and cocks are to be at all times readily accessible and are to be capable of being shut off from positions above the bulkhead deck. Indicators are to be provided to show whether the drains are open or shut. These arrangements are not permissible in passenger ships. (For drainage of stern compartments, *see* 210.)

264 Valve chests, cocks, pipes or other fittings attached direct to the plating of tanks, and to bulkheads, flats or tunnels which are required to be of watertight construction, are to be secured by means of studs screwed through the plating or by tap bolts and not by bolts passing through clearance holes.

Alternatively, the studs or the bulkhead piece may be welded to the plating.

Deep Tanks

265 In the case of deep tanks which may be used for either water ballast or dry cargo, provision is to be made for blank flanging the water ballast filling and suction pipes when the tank is being used for the carriage of dry cargo and for blank flanging the bilge suction pipes when the tank is being used for the carriage of water ballast.

Change-over devices may be used for this purpose. (For arrangements when oil fuel or cargo oil is carried in deep tanks, *see* E 324.)

Hold Bilge Valves

266 Where non-return valves are fitted to the open ends of bilge suction pipes in cargo holds in order to decrease the risk of flooding, they are to be of an approved type which does not offer undue obstruction to the flow of water.

Ship Side Valves (other than those on Scuppers and Sanitary Discharges)

267 All sea inlet and overboard discharge pipes are to be fitted with valves or cocks secured direct to the shell plating or to the plating of fabricated steel water boxes attached to the shell plating. These fittings are to be secured by bolts tapped into the plating and fitted with countersunk heads or by studs screwed into heavy steel pads fitted to the plating. The stud holes are not to penetrate the plating.

Distance pieces of short rigid construction, and made of approved material as required by 270, may be fitted between the valves and shell plating. Distance pieces of steel may be welded to the shell plating. Details of the welded connections and of fabricated steel water boxes are to be submitted.

268 All suction and discharge valves and cocks direct on the shell plating of the ship are to be fitted with spigots passing through the plating, but the spigots on the valves or cocks may be omitted if these fittings are attached to pads or distance pieces which themselves form spigots in way of the shell plating.

Blow-down cocks or valves are also to be fitted with a protection ring through which the spigot is to pass, the ring being on the outside of the shell plating.

Blow-down cocks or valves on the ship's side are to be fitted in accessible positions above the level of the working platform and are to be arranged so that it can be readily seen whether they are open or shut. Cock handles are not to be capable of being removed unless the cocks are shut, and if valves are fitted, the wheels are to be fixed to the spindles.

269 Sea inlet and overboard discharge cocks and valves are in all cases to be fitted in easily accessible positions and, as far as practicable, are to be readily visible.

Provision is to be made for preventing any discharge of water into lifeboats.

The inlet valve spindles are to extend above the lower platform, and the hand wheels of the main injection and bilge injection valves are to be situated not less than 18 inches above this platform.

270 Where valves or cocks are over 3 inches bore, they are to be of steel or an approved grade of cast iron or other approved material; this requirement applies equally to inlet chests, distance pieces, and other sea connections.

All these fittings, if made of steel, are to be suitably protected against wastage.

271 The scantlings of valves and valve stools fitted with steam or compressed air clearing connections are to be suitable for the maximum pressure to which the valves and stools may be subjected.

Cross-reference

272 For sea connections for ships having notation for ice navigation, *see* H 809 to H 811.

Miscellaneous Requirements

273 All pipes situated in cargo spaces, coal bunkers, chain lockers or other positions where they are liable to mechanical damage are to be efficiently protected. (*See* D 2519, quoted at end of this Section, and D 2412, quoted at end of E 4.)

274 Wash deck pipes and discharge pipes from the pumps to domestic water tanks are not to be led through cargo holds if, as is generally the case, it is practicable to avoid doing so. Any proposed departure from this requirement is to be submitted.

275 As far as practicable, pipe lines, including exhaust pipes from oil engines, are not to be led in the vicinity of switchboards or other electrical appliances in positions where drip or escape of liquid, gas or steam from joints or fittings may cause damage to the electrical installation.

Where it is not practicable to comply with these requirements, drip trays or shields are to be provided as found necessary.

Short sounding pipes to tanks should not terminate near electrical appliances (*see* E 413).

Extract from Chapter D for reference

Scuppers

D 2508 Scuppers sufficient in number and size to provide effective drainage are to be fitted in all decks.

D 2509 When the weather deck stringer angle is cut in way of scuppers compensation is to be provided.

D 2510 Scupper pipes which drain spaces below the freeboard deck are to be led to the bilges, or may be led overboard provided the spaces drained are above the load waterline and the scuppers are fitted with screw-down non-return valves capable of being operated from a position always accessible and above the freeboard deck. Means are to be provided for showing whether the valves are open or closed.

D 2511 Scuppers draining spaces in intact superstructures or in superstructures having the openings in the end bulkheads closed by strong hinged steel doors may be led to the bilges or may be led overboard and fitted if considered necessary with screwdown non-return valves as required by 2510.

D 2512 Scuppers draining spaces in short superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are to be led overboard, with the exception of the scuppers above the machinery space which may be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

D 2513 Scuppers which drain overboard from spaces referred to in 2511 and 2512 and which are not required to have storm valves with positive means of control are to be fitted with non-return valves of automatic type.

D 2514 Scuppers draining spaces in long superstructures having the openings in the end bulkheads closed by appliances as described in D 2301 are, within the range of the machinery space, to be led to the bilges where the lower ends of the pipes are to be visible and readily accessible.

Where additional scuppers are required to ensure effective drainage of the spaces clear of the machinery space these scuppers are to be led to the hold bilges and fitted with screw-down valves at the freeboard deck, the valves being controlled from a position which is accessible at all times above the freeboard or superstructure deck. Means are to be provided for showing whether the valves are open or closed.

D 2515 Plans showing the arrangement of scuppers for draining refrigerated cargo compartments are to be submitted for consideration.

Sanitary Discharges

D 2516 Sanitary discharges from spaces below the freeboard deck are to be provided with efficient and accessible means of preventing water from passing inboard.

Each discharge is to have a screw-down automatic non-return valve operated from an accessible position above the freeboard deck. Means are to be provided for showing whether the valve is opened or closed.

Alternatively, two automatic non-return valves, without positive means of closing, may be fitted provided the upper valve is in a position which is always accessible for examination.

D 2517 Discharges from spaces within enclosed superstructures are each to be fitted with automatic non-return valves, but arrangements similar to those described in 2516 may be required.

Materials for Valves and Pipes

D 2518 Castings enclosing non-return valves are to be of substantial construction. These castings, also the elbow pieces where no valves are required, are to be of approved material other than ordinary cast iron. The length of pipe attached to the valve or elbow piece is to be of galvanised steel of standard steam pipe quality.

Protection of Pipes and Valves

D 2519 In all cargo spaces or coal bunkers, scupper pipes, discharges and screw-down valves and their controls are to be well protected; in coal bunkers the protection is to be of steel.

Section 3

OIL FUEL AND CARGO OILS HAVING A FLASH POINT ABOVE 150° F.

General

301 In addition to the special requirements detailed in this Section, the requirements of E 2 relating to bilge and ballast are to be complied with in so far as they are applicable to the drainage of tanks, oil bilges and cofferdams.

302 The flash point (closed test) of oil fuel for use in steam and motor ships classed for unrestricted service is in general not to be less than 150° F. For emergency generator engines a flash point of not less than 110° F. is permissible.

Fuels with flash points lower than 150° F. may be used in ships intended for service restricted to geographical limits where it can be ensured that the temperature of the machinery and boiler spaces will always be 30° F. below the flash point of the fuel. In such cases, safety precautions and the arrangements for storage and pumping will be specially considered. However, in no case is the flash point of the fuel to be less than 130° F. when supplied for oil fired boilers or less than 110° F. for oil engines.

When it is desired to carry a quantity of fuel having a flash point below 110° F. for special services, e.g. aviation spirit for use in helicopters, full particulars of the proposed arrangements are to be submitted for special consideration.

Oil Fuel Pumps and Oil Burning Appliances

303 In every ship where steam for the main propelling engines, or for auxiliary machinery which is required for essential services, is generated by burning oil fuel under pressure, there are to be not less than two oil burning units, each unit comprising a pressure pump, a suction filter, a discharge filter and a heater.

In two unit installations, each unit is to be capable of supplying fuel for generating all the steam required for essential services.

In installations of three or more units, the capacities and arrangements of the units are to be such that all the steam required for essential services can be maintained with any one unit out of action.

304 Unit pressure pumps for the oil burning system are to be entirely separate from the feed, bilge or ballast systems.

305 In systems where oil is fed to the burners by gravity, duplex filters are to be fitted in the supply pipe line to the burners and so arranged that one filter can be opened up when the other is in use.

306 If oil fuel is sprayed by steam, means are to be provided to carry or make up the fresh water used for this purpose.

307 A starting-up oil fuel unit, including an auxiliary heater and hand pump, or other suitable starting-up device, which does not require power from shore, is to be provided.

308 All pumps used in connection with oil fuel are to be provided with effective escape valves which are to be in close circuit, i.e., discharging back to the suction side of the pumps.

Escape valves are also to be fitted on the oil side of the heaters, discharging to the pump suction line, to the tray under the unit, or to other approved position, and are to be adjusted to operate at a pressure of 50 lb. per square inch above that of the pump escape valve.

309 Where a power driven transfer pump is necessary for pumping up the settling tanks in motorships and steamships, a stand-by pump is to be provided and connected ready for use, or alternatively, emergency connections may be made to one of the unit pumps or to another suitable power driven pump.

Oil Pipes and Fittings

310 Pipes conveying heated oil under pressure are to be of seamless steel having flanged couplings and placed in sight above the platform in well lighted parts of the stokehold or engine room.

The flanges are to be machined and the jointing material, which is to be impervious to oil heated to 250° F., is to be the thinnest possible, so that the flanges are practically metal to metal. The scantlings of the pipes and their flanges are to be suitable for at least 200 lb. per square inch working pressure, or the pressure to which the relief valves are adjusted, whichever is the greater.

The pipes, heaters and their fittings are to be tested after jointing to not less than 400 lb. per square inch, or twice the working pressure, whichever is the greater.

The thickness of the oil fuel pressure pipes is to be determined from the formula contained in E 512.

311 The short joining lengths of pipes to the burners from the control valves on the boiler front may have cone unions of specially robust construction.

Flexible pipes of approved material and design may be used for the burner pipes provided spare lengths, complete with couplings, be carried on board.

A quick closing master valve is to be fitted on the hot oil supply to each boiler manifold.

312 Transfer, suction and other low pressure oil pipes and all pipes passing through oil storage tanks are to be made of cast or wrought iron or steel, having flanged joints suitable for a working pressure of not less than 100 lb. per square inch. The flanges are to be machined and the jointing material is to be impervious to oil. Oil pipes within the engine and boiler spaces are to be fitted where they can be readily inspected and repaired, and after jointing they are to be tested to 50 lb. per square inch, or twice the maximum working pressure, whichever is the greater.

Valves and Cocks

313 The valves, cocks and their pipe connections are to be so arranged that oil cannot be admitted into tanks which are not structurally suitable for the carriage of oil or into tanks which can be used for the carriage of fresh water intended for boiler feed or for drinking.

In passenger ships provision is to be made for the transfer of oil fuel from any oil fuel storage or settling tank to any other oil fuel storage or settling tank in the event of fire or damage.

314 Every oil fuel suction pipe from a double bottom tank is to be fitted with a valve or cock.

315 Every oil fuel suction pipe from a storage, settling and daily service tank situated above the double bottom and every oil fuel levelling pipe within the boiler

room or engine room is to be fitted with a valve or cock secured to the tank. In the case of fore peak tanks, these valves are to be fitted on the tank side of the bulkhead.

In the engine and boiler spaces, such valves and cocks are to be capable of being closed locally and from positions which will always be accessible in the event of fire taking place in these spaces. Indicators are to be provided at the valves and cocks and at the remote control positions to show whether they are open or shut.

In the case of very small tanks consideration will be given to the omission of remote controls.

316 Every oil fuel suction pipe which is led into the engine and boiler spaces from a tank situated above the double bottom outside these spaces is to be fitted in the machinery space with a remote controlled valve, except where the valve on the tank is already remote controlled.

317 All valves and cocks forming part of the oil fuel installation are to be capable of being controlled from readily accessible positions which, in the engine and boiler spaces, are to be above the working platform.

Valves or cocks are to be interposed between the pumps and the suction and discharge pipes, in order that any pump may be shut off for opening up and overhauling.

Oil fuel valves are to be so constructed as to prevent the possibility of any cover being slacked back or loosened when operating the valves. The valves and cocks are to be fitted with legible nameplates.

318 Where the filling pipes to deep oil tanks are not connected to the tanks near the top, they are to be provided with non-return valves at the tanks or with valves or cocks fitted and controlled as in the case of the outlet valves or cocks on these tanks.

319 Open drains for removing the water from oil tanks are to be fitted with cocks or valves of self-closing type and suitable provision is to be made for collecting the oily discharge.

Oil Fired Galleys

320 The fuel oil tank is to be located outside the galley and is to be fitted with approved means of filling and venting. The fuel supply to the burners is to be controlled from a position which will always be accessible in the event of a fire occurring in the galley. The galley is to be well ventilated.

When liquefied petroleum gas is used similar provisions are to be made.

Filling Arrangements

321 In passenger ships, the filling station is to be isolated from other spaces and is to be efficiently drained and ventilated. Provision is to be made against overpressure in the filling pipe lines and any relief valve fitted for this purpose is to discharge to an overflow tank or other safe position.

Alternative Carriage of Oil Fuel and Water Ballast

322 Where it is intended to carry oil fuel and water ballast in the same compartments alternatively, the valves or cocks connecting the suction pipes of these compartments with the ballast pump and those connecting them with the oil fuel transfer pump are to be so arranged that the oil may be pumped from any one compartment by the oil fuel pump at the same time as the ballast pump is being used on any other compartment.

Where settling or service tanks are fitted, each having a capacity sufficient to permit of 12 hours' normal service without replenishment, the above requirement may be dispensed with.

323 Attention is drawn to the statutory regulations issued by National Authorities in connection with the International Convention for Prevention of Pollution of the Sea by Oil, 1954.

Deep Tanks for the Alternative Carriage of Oil, Water Ballast or Dry Cargo

324 In the case of deep tanks which can be used for the carriage of oil fuel, cargo oil, water ballast or dry cargo, provision is to be made for blank flanging the oil and water ballast filling and suction pipes, also the steam heating coils if retained in place, when the tank is used for dry cargo and for blank flanging the bilge suction pipes when the tanks are used for oil or water ballast.

If the deep tanks are connected to an overflow system, the arrangements are to be such that liquid or vapour from other tanks cannot enter the deep tanks when dry cargo is carried in them.

Oily Bilge Drainage and Sediment Suctions

325 Provision is to be made for the drainage of oil gutterways, oil wells and cofferdams. (*See* D 2024 to D 2027, quoted at end of this Section.)

Fresh Water Piping

326 Pipes in connection with compartments used for storing boiler feed water are to be separate and distinct from any pipes which may be used for oil or oily water, and are not to be led through tanks which contain oil, nor are oil pipes to be led through boiler feed water tanks.

Similar precautions are necessary when the connections are such that fresh water carried in other tanks can be used as reserve feed water.

Service, Settling and other Oil Fuel Tanks

327 In general, the minimum thickness of the plating of these tanks, when they do not form part of the structure of the ship, is to be $\frac{1}{4}$ inch, but in the case of very small tanks, the minimum thickness may be $\frac{1}{8}$ inch. Adequate stiffening of the plating is to be provided where necessary.

On completion the tanks are to be tested by a head of water equal to the maximum to which the tanks may be subjected but not less than 8 feet above the crown of the tank.

Water Drainage from Settling Tanks

328 Settling tanks are to be provided with means for draining water from the bottom of the tanks.

If settling tanks are not provided, the oil fuel bunkers or daily service tanks are to be fitted with water drains (*see* 319).

Ventilation

329 The spaces in which the oil fuel burning appliances, and the oil fuel settling and service tanks are fitted, are to be well ventilated and easy of access.

Boiler Insulation and Air Circulation in Boiler Room

330 The boilers are to be suitably lagged. The clearance spaces between the boilers and tops of the double bottom tanks and between the boilers and the sides of the storage tanks in which oil fuel or cargo oil is carried, are to be adequate for the free circulation of air necessary to keep the temperature of the stored oil well below its flash point.

331 Where water tube boilers are installed, there should be a space of at least 2 feet 6 inches between the tank top and the underside of the pans forming the bottom of the combustion spaces.

332 Smoke-box doors are to be shielded and well fitting, and the uptake joints made airtight.

Funnel Dampers

333 Dampers which are capable of completely closing the gas passages are not to be fitted to inner funnels of ships equipped for burning oil fuel only. In ships burning oil or coal alternatively, dampers may be retained if they are provided with a suitable device whereby they may be securely locked in the fully open position.

Steam Heating Arrangements

334 Where steam is used for heating oil fuel, cargo oil or lubricating oil, either in bunkers, tanks, heaters or separators, the exhaust drains are to discharge the condensate into an observation tank in a well lighted and accessible position where it can be readily seen whether or not it is free from oil (*see* E 1118).

335 The steam heating pipes in contact with oil are to be of iron, steel, approved aluminium alloy or approved copper alloy and are to be tested, after being fitted on board, to twice the maximum pressure to which they can be subjected.

336 The working pressure of steel steam heating pipes is to be determined from the formula in E 512.

Control of Pumps

337 The power supply to the oil fuel transfer and unit pressure pumps and to the cargo oil pumps is to be capable of being stopped from a position which will always be accessible in the event of fire taking place in the compartment in which they are situated, as well as from the compartment itself.

Precautions against Fire

338 Settling and daily service oil fuel tanks and oil fuel filters are not to be situated immediately above boilers or other highly heated surfaces.

339 Oil fuel pressure pipes are to be led, wherever practicable, remote from heated surfaces and electrical appliances, but where this is impracticable, the pipes are to have a minimum number of joints and are to be led in well lighted and readily visible positions.

340 Short sounding pipes to oil fuel tanks are not to be situated adjacent to boilers or to electric generators or motors. (For alternative sounding arrangements, *see* E 414.)

341 Water service pipes and hoses are to be fitted in order that the floor plates and tank top or shell plating in way of boilers, oil fuel apparatus or deep storage tanks in the engine and boiler spaces can at any time be flushed with sea water.

342 So far as is practicable the use of wood is to be avoided in the engine rooms, boiler rooms and tunnels of ships burning oil fuel.

343 Drip trays are to be fitted at the furnace mouths to intercept oil escaping from the burners and under all other oil fuel appliances which require to be opened up frequently for cleaning or adjustment. The arrangements are to be such that a burner cannot be withdrawn unless the oil fuel supply to that burner is shut off.

For alternately fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

Separation of Cargo Oils from Oil Fuel

344 Pipes conveying vegetable oils or similar cargo oils are not to be led through oil fuel tanks, nor are oil fuel pipes to be led through tanks containing these cargo oils. (*See* D 2105, quoted at end of this Section.)

Oil Drainage in way of Refrigerated Cargo Chambers

345 The insulation of all oil storage tank tops is to have an air space of 2 inches provided between the under side of the insulation and the tank top plating and the supporting battens are to be arranged to provide free drainage to the bilges. Alternatively, either $\frac{1}{2}$ inch thick inodorous material, or successive coatings of approved oil resisting compositions to a total thickness of about $\frac{3}{16}$ inch may be applied to the tank top plating.

346 A cofferdam is to be fitted separating deep tanks intended for the carriage of oil from refrigerated compartments unless the tank bulkhead is wholly welded including its boundary connections, in which case the cofferdam may be omitted and an air space of not less than 2 inches arranged between the insulation and the bulkhead plating to provide for free drainage from the latter into the oil gutterway and thence to the bilges.

Provision is to be made for ventilating the cofferdam or air space, the vents being led to the open air and their outlets being fitted with a wire gauze diaphragm which can easily be removed for renewal.

Extracts from Chapter D for reference

Protection and Drainage

D 2023 Compartments carrying oil are to be separated by cofferdams from those carrying fresh water; oil fuel compartments are to be similarly separated from those carrying vegetable oil. Cofferdams are to be suitably ventilated.

D 2024 Sparring or lining is to be fitted on the bulkheads in holds to prevent leakage of oil coming into contact with the cargo. Gutterways are to be arranged at the foot of these bulkheads to ensure that leakage shall have free drainage to the wells or limbers. Gutterways are also to be fitted in boiler spaces.

D 2025 Where a bulkhead, including its boundary connections, is wholly welded, the requirements of 2024 may be dispensed with, except that a gutterway is to be fitted in the boiler room.

D 2026 Ceiling on the inner bottom, if fitted, is to be laid on battens not less than $\frac{1}{2}$ inch in thickness. Battens are to be so laid as to permit the drainage of oil to the bilges or wells.

D 2027 Drip trays or gutterways, with suitable draining arrangements, are to be provided for all tanks which do not form part of the hull structure, at pumps, valves and elsewhere where there is a possibility of leakage. Drip trays are also to be fitted under oiltight decks, except if these are completely welded when the drip trays need only be fitted over the boilers.

D 2028 If cargo or coal is carried in a compartment adjacent to an oil fuel settling tank which may be heated, the compartment side of the bulkhead or deck is to be insulated.

Vegetable and Similar Oils

D 2105 Deep or peak tanks carrying vegetable or similar oils are to be separated from those carrying oil fuel or fresh water, by a cofferdam.

Section 4

AIR, OVERFLOW AND SOUNDING PIPES

Air and Overflow Pipes

401 Air pipes are to be fitted at the opposite end of the tank to that at which the filling pipes are placed and/or at the highest part of the tank.

Where the tank top is of unusual or irregular profile special consideration will be given to the number and position of the air pipes.

Nameplates are to be affixed to the upper ends of all air pipes.

402 Air pipes to double bottom tanks, deep tanks extending to the shell plating or tanks which can be run up from the sea are to be led to above the bulkhead deck.

Air pipes to oil fuel and cargo oil tanks, cofferdams and all tanks which can be pumped up are to be led to the open. (For height of air pipes above deck, *see* D 2409, quoted at end of this Section.)

403 The open ends of air pipes to oil fuel and cargo oil tanks are to be situated where no danger will be incurred from issuing oil or vapour when the tank is being filled and each opening is to be furnished with a wire gauze diaphragm of incorrodible material which can be readily removed for cleaning or renewal.

404 Air pipes from lubricating oil storage tanks may terminate in the machinery space, provided the open ends are so situated that issuing oil cannot come into contact with electrical equipment or heated surfaces.

405 The closing appliances fitted to tank air pipes, in accordance with D 2410, are to be of a type which will prevent excessive pressure coming on the tanks.

Provision is to be made for relieving vacuum when the tanks are being pumped out and for this purpose a hole about $\frac{3}{8}$ inch in diameter in the bend of the air pipe or in a suitable position in the closing device will be acceptable.

406 In the case of all tanks which can be pumped up, either by the ship's pumps or by shore pumps through a filling main, the total cross-sectional area of the air pipes to each tank or of the overflow pipes where an overflow system is provided, is to be not less than 25 per cent greater than the effective area of the respective filling pipes.

Where tanks are fitted with cross flooding connections the air pipes are to be of adequate area for these connections. Wood plugs and other devices which can be secured closed are not to be fitted at the outlets.

In wire gauze diaphragms at air pipe openings, the area of the clear opening is to be not less than the cross-sectional area required for the pipe.

Air pipes are to be not less than 2 inches bore.

407 The arrangement of the overflow system is to be such that in the event of any one of the tanks being bilged, tanks situated in other watertight compartments of the ship cannot be flooded from the sea through the overflow main.

Air and overflow pipes are to be arranged to be self-draining under normal conditions of trim.

408 Overflow pipes are to be fitted to oil fuel storage, settling and daily service tanks when the pressure head corresponding to the height of the air pipe is greater than that for which the tanks are suitable or when the sectional area of the air pipe is less than required by 406.

The pipe is to be led to an overflow tank of adequate capacity or to a storage tank having a space reserved for overflow purposes.

A sight glass is to be provided in the overflow pipe to indicate when the tanks are overflowing or, alternatively, an alarm device is to be provided to give warning either when the tanks are overflowing or when the oil reaches a predetermined level in the tanks.

409 Where overflows from tanks which are used for the alternative carriage of oil and water ballast are connected to an overflow system, arrangements are to be made to prevent water ballast overflowing into tanks containing oil (*see* also E 324.)

410 Air and overflow pipes are to be of steel or wrought iron and should have a minimum thickness of ·19 inch. Pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

The portions of air and overflow pipes fitted above deck are to be of steel, wrought iron or other approved ductile material and of robust construction.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

Sounding Pipes

411 Provision is to be made for sounding all tanks, and the bilges of those compartments which are not at all times readily accessible.

The soundings are to be taken as near the suction pipes as practicable.

412 Sounding pipes, including those for the double bottom tanks below the machinery spaces, should be led to positions above the bulkhead deck which are at all times accessible.

These pipes should be as straight as practicable, and if curved to suit the structure of the ship, the curvature must be sufficiently easy to permit the ready passage of the sounding rod or chain.

Nameplates are to be affixed to the upper ends of all sounding pipes.

413 In machinery spaces and tunnels where it is not always practicable to extend the sounding pipes as mentioned in 412, short sounding pipes extending to readily accessible positions above the platform may be fitted, provided those to oil fuel and lubricating oil tanks are not situated adjacent to boilers or electric generators or motors, and are fitted with cocks having parallel plugs with permanently attached handles so loaded that, on being released, they automatically close the cocks.

Short sounding pipes to tanks other than oil tanks are to be fitted with shut-off cocks or with screw caps attached to the pipes by chains.

In passenger ships, short sounding pipes are permissible only for sounding cofferdams and double bottom tanks situated in the machinery space and are in all cases to be fitted with self-closing cocks as described in the foregoing.

414 Tank sounding devices of approved type may be used in lieu of sounding pipes. These devices are to be tested, after fitting on board, to the satisfaction of the Surveyors.

415 If gauge glasses are used for indicating the level of liquid in tanks containing lubricating oil, oil fuel or other inflammable liquid, the glasses are to be of heat-resisting quality adequately protected from mechanical damage and fitted with self-closing valves at the lower ends and at the top ends if these are connected to the tanks below the maximum liquid level.

416 Sounding pipes to oil compartments are not to terminate within refrigerated cargo chambers or in the fan and battery rooms for these chambers, nor are these pipes to terminate in enclosed spaces from which access is provided to refrigerated cargo chambers or their fan and battery rooms, if it be practicable to avoid doing so.

Where these sounding pipes do terminate in such spaces they are to be fitted with self-closing cocks having parallel plugs.

417 Sounding pipes are to be not less than $1\frac{1}{4}$ inches bore. All sounding pipes, whether for compartments or tanks, which pass through refrigerated spaces, or the insulation thereof, in which the temperatures contemplated are 32° F. or below, are to be not less than $2\frac{1}{2}$ inches bore.

418 All pipes, including scupper pipes, air pipes and sounding pipes which pass through chambers intended for the carriage or storage of refrigerated produce are to be well insulated.

Where such pipes pass through chambers intended for a temperature of 32° F. or below they are also to be insulated from the steel structure except in positions where the temperature of the structure is mainly controlled by the external temperature and will normally be above freezing point. Pipes passing through a deck plate within the ship side insulation, where the deck is fully insulated below and has an insulation ribband on top, are to be attached to the deck plating.

In the case of pipes adjacent to the shell plating, metallic contact between the pipes and the shell plating or frames is to be arranged as far as practicable.

The air refreshing pipes to and from refrigerated compartments need not, however, be insulated from the steel work.

419 Sounding pipes are to be of steel or wrought iron and should have a minimum thickness of ·17 inch. Pipes slightly less in thickness may be accepted, provided they be suitably coated to prevent corrosion. Where not in contact with oil fuel or cargo oil, suitable protection may be provided by galvanising the pipes on completion.

Where flanged connections are employed, heavy flanges with closely spaced bolts are to be fitted.

420 Striking plates of adequate thickness and size are to be fitted under open ended sounding pipes.

When slotted sounding pipes having closed ends are employed, the closing plugs are to be of substantial construction.

421 Elbow sounding pipes are not to be used for deep tanks unless the elbows and pipes are situated within closed cofferdams or within tanks containing similar liquids.

They may, however, be fitted to other tanks and may be used for sounding bilges, provided it is not practicable to lead them direct to the tanks or compartments.

The elbows are to be of heavy construction and adequately supported.

In passenger ships, elbow sounding pipes are not permissible.

Extract from Chapter D for reference

Air and Sounding Pipes

D 2409 The height of air pipes, from upper surface of deck to opening, on decks exposed to the weather, is to be as follows:—

On the uppermost continuous deck where the draught is the maximum permitted for the dimensions of the ship, with the depth D measured to that deck .... 36 inches.

On raised quarter decks .... 30 inches.

On superstructure decks other than raised quarter decks, but including those extending for the full length of the ship .... 18 inches.

D 2410 Openings of air and sounding pipes are to be provided with satisfactory arrangements to prevent the free entry of water.

D 2411 Striking plates of sufficient thickness, or their equivalent, are to be fitted under all sounding pipes.

D 2412 In all cargo spaces or coal bunkers, air and sounding pipes are to be well protected and in coal bunkers the protection is to be of steel.

Section 5

PRESSURE PIPES

Copper Pipes

501 Pipes made from the electro-deposition of copper on a mandril are not to be used.

502 Pipes are to be carefully annealed on completion and prior to testing by hydraulic pressure.

503 All pipes which are subject to a working pressure over 75 lb. per square inch are to be seamless.

504 Steam pipes intended for a working pressure over 180 lb. per square inch are not to be of copper when the internal diameter exceeds 5 inches.

505 Copper pipes are not to be used for a temperature above 425° F.

506 The working pressure to be allowed on copper pipes is to be determined by the following formula:—

$$WP = \frac{(t-3) \times F}{d} \quad \text{or} \quad t = \frac{WP \times d}{F} + 3$$

where WP = working pressure, in lb. per square inch, which, in the case of feed pipes, is to be taken as 1·25 times the boiler pressure,

d = internal diameter, in inches,

t = thickness, in 100ths of an inch,

F = 60 for seamless pipes,
45 for brazed pipes.

507 Where copper pipes are bent, they are to be made thicker by 1 S.W.G. (approximately ·02 inch) than required by 506 to provide for thinning at the bend.

In no case is the radius of curvature at the centre line of the pipe to be less than twice the external diameter of the pipe.

Steel Pipes

508 Steel pipes are to comply with the material requirements of P 9. For alloy steels particulars of chemical composition, deoxidising mediums and operating temperature are to be submitted for approval. Similar particulars are also to be submitted for carbon steel where the proposed operating temperature exceeds 750° F. The temperature limitations indicated in Table 1 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

509 Pipes of seamless or other approved type are to be used for feed pipes, for pressure pipes conveying heated oil and for other pressure pipes where the working pressure exceeds 250 lb. per square inch or the temperature exceeds 425° F.

510 Pipes other than those mentioned in 509 may be lap welded provided they are made by an approved mechanical process.

511 Pipes having forge butt welded longitudinal seams are not to be used for oil fuel systems, for heating coils in oil tanks, or for pressures exceeding 50 lb. per square inch.

512 The thickness of steel pipes intended for steam, feed, air, oil fuel and other pressure services is to be determined by the following formula and the thickness so obtained is suitable for straight pipes and pipes which are to be bent.

The formula does not provide for adverse corrosion conditions and steam and feed pipes over 1 inch bore intended for use with low pressure boilers (up to 250 lb. per square inch working pressure) and any boilers with open feed systems are to be made one gauge (about ·02 inch) thicker than required by the formula.

The formula also makes provision for a manufacturing tolerance of—15 per cent and where tubes are specified to a closer negative tolerance than this figure, the rule thickness may, if desired, be reduced to suit the specified tolerance.

Seamless pipes for all pressures and temperatures:

$$t = \left(\frac{WP \times D}{2f} + \cdot 05\right) 1 \cdot 275$$

(For lap welded pipes for pressures up to 250 lb. per square inch and temperatures up to 425° F. the thickness is to be 50 per cent greater than required for seamless pipes).

Where t = thickness of pipe, in inches,

WP = working pressure, in lb. per square inch.

For feed pipes, WP is to be taken as 1·25 times the boiler pressure, or the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

With water tube boiler installations, WP is to be taken as the approved boiler pressure for steam pipes between the boiler and integral superheater and as the pressure to which the superheater safety valves are set for the steam pipes leading from the superheater. Where the superheater safety valves are controlled by pilot valves operated from the saturated steam drum then WP for the steam pipes leading from the superheater is to be taken as the boiler pressure.

NOTE.—In installations where the boiler pressure, as controlled by the safety valve settings, is less than the approved boiler pressure it will be permissible for thicknesses of external steam and feed pipes to be based on the former.

D = outside diameter of pipe, in inches,

f = nominal stress in lb. per square inch with the following values:—

For temperatures up to and including 650° F.

f is to be taken as $\frac{1}{5}$ of the specified minimum tensile strength of the pipe material. Values of f are given in the first column of Table 1 for representative carbon steels and may be obtained on the foregoing basis for any other carbon or low alloy pipe steel approved for pressure service.

TABLE 1

PIPE STEEL	Minimum tensile strength Tons per square inch	STEAM PIPES—NOMINAL STRESS IN LB. PER SQUARE INCH AT FOLLOWING STEAM TEMPERATURES IN ° F.								
		650	700	750	800	850	900	950	1000	1050
Carbon	23	10300	9800	9200	8400	7600	5000			
	27	12100	11500	10800	9300	7600	5000			
½% Mo.	25	11200	11200	11200	11000	10800	*			
	28	12500	12500	12500	12400	12100	*			
½% Cr., ½% Mo.	25	11200	11200	11200	11000	10800	10400	7500		
	28	12500	12500	12500	12400	12100	11000	7500		
1% Cr., ½% Mo.	27	12100	12100	12100	12100	12000	11500	7800	4800	
2¼% Cr., 1% Mo.	27	12100	12100	12100	12100	12000	11500	8400	6000	4600
½% Mo., ¼% V.	31	13900	13900	13900	13900	13900	13800	11000	7000	5200

* ½% Mo. material is not recommended for higher temperatures than 850° F. because of its poor rupture ductility.

For temperatures above 650° F.

f is to be taken from Table 1 which gives values of f for a limited number of pipe steels of approved composition in common use for superheated steam pipe service. Values of f for other steels will receive special consideration.

Steam temperature is to be taken as the designed operating temperature for the pipe line provided the temperature at the superheater outlet is closely controlled. Where temperature fluctuations exceeding 25° F. above the designed temperature are to be expected in normal service the steam temperature for use with the Table is to be increased by the amount of this excess.

For intermediate temperatures, values of f may be obtained by interpolation.

Where it is proposed to use, for high temperature service, alloy steels other than those stated in the Table, particulars of tube sizes, working conditions and appropriate British or other national standard material specification giving the data required by 508 are to be submitted for consideration.

Where the material does not conform to an established standard, particulars of chemical composition, deoxidising medium, heat treatment, mechanical properties and measured or estimated long-term creep and rupture data at the proposed operating temperature are to be submitted for the purpose of assessing a safe working stress.

Steel Pipe Flanges and Branch Pieces

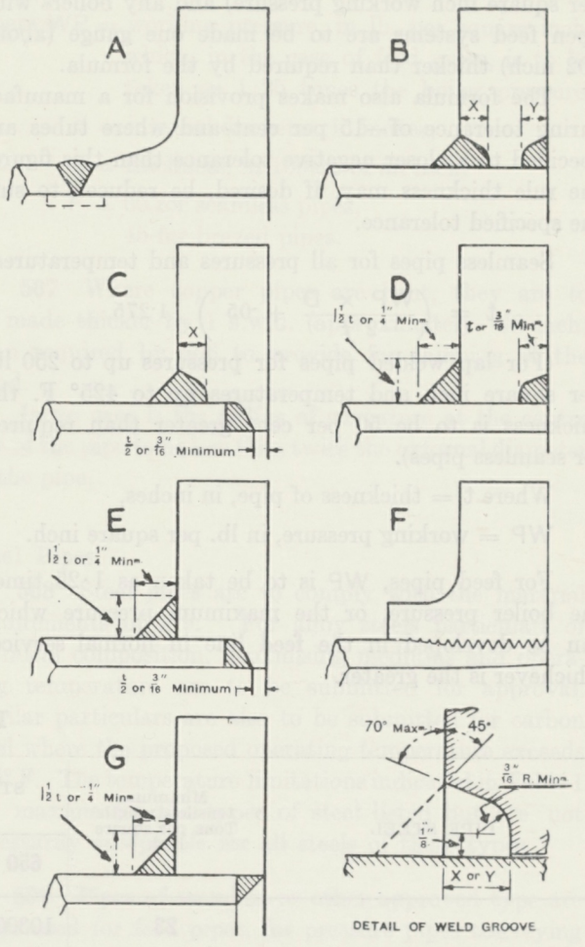
513 Flanges are to be weldless and of material suitable for the working temperature. They may be attached to pipes by screwing and expanding or by welding. Acceptable methods of attachment are illustrated and Table 3 indicates the pressures and temperatures for which the various types are acceptable.

If backing rings are used with flange type A they are to fit closely to the bore of the pipe. The rings are to be made of the same material as the pipes or of good quality mild steel having a sulphur content not greater than 0·06 per cent. Flange types C and E are unsuitable for pipes under 3 inches bore.

Alternative methods of flange attachment and other types of pipe joints may be accepted provided details are submitted for special consideration.

For flange types B and C, dimension X is to be taken as t for carbon steel and $1\frac{1}{2}$t for alloy steel pipes but is to be not less than shown in Table 2.

ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL PIPES



For flange type B, dimension Y is to be taken as t for carbon steel and $1\frac{1}{2}$t for alloy steel pipes but is to be not less than $\frac{3}{16}$ inch.

t is to be taken as the rule thickness of the pipe.

TABLE 2

Pipe Bore	Dimension X Minimum
$\frac{1}{2}$″ and $\frac{3}{4}$″	$\frac{1}{4}$″
1″ to $1\frac{1}{2}$″	$\frac{5}{16}$″
2″ and over	$\frac{3}{8}$″

TABLE 3

Type of Flange Attachment	Service and Rating			
	Feed, Air, Oil Fuel and other fluids		Steam	
	Pressure lb. per sq. in.	Temperature °F.	Pressure lb. per sq. in.	Temperature °F.
A	All Conditions		All Conditions	
B & C	All Conditions		750	850
D & E	750	500	550	750
F	600		450	
G	250		250	500

514 Where flanges are attached by screwing, the pipe and flange are to be screwed with a vanishing thread and the diameter of the screwed portion of the pipe over the thread must not be appreciably less than the outside diameter of the unscrewed pipe. After the flange has been screwed hard home the pipe is to be expanded into the flange.

The vanishing thread on a pipe is to be not less than three pitches in length, and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

515 When flanges are attached by welding using the oxy-acetylene or metal arc process the filler rods and electrodes used are to be suitable for the materials of the parts to be joined.

In general oxy-acetylene welding is suitable only for flange type A and is not to be applied to pipes exceeding 4 inches diameter or $\frac{3}{8}$ inch thick.

Preheating is to be employed when necessitated by the dimensions and composition of the materials to be welded and is to be effected by a method which ensures uniformity of temperature at the joint. Particulars are to be submitted.

Where butt welds are employed in the attachment of flange type A or in the construction of branch pieces, the adjacent pieces are to be matched at the bores. This may be effected by drifting, roller expanding, or machining provided the pipe wall is not reduced below the designated thickness.

Butt welds are to be reinforced externally by additional runs of weld metal. All welds in high pressure and high temperature pipe lines are to have a smooth surface and even contour; if necessary they are to be made smooth by grinding. No undercutting of the pipe at the edges of the weld is acceptable.

516 Branches may be attached to pressure pipes by means of welding provided the pipe is reinforced at the branch by a compensating plate or collar or other approved means, or alternatively the thicknesses of pipe and branch are to be increased to maintain the strength of the pipe.

These requirements also apply to fabricated branch pieces.

517 The welding procedure proposed for the attachment of flanges to pipes and the fabrication of branch pieces, whether in carbon or alloy steel, is to be approved by the Surveyors in the first instance before work is commenced. For this purpose representative specimens of a pipe section with welded-on flange or attached branch pipes will be required for examination and test.

Sections are to be taken from the joints at selected positions and are to be macro-etched to ascertain that welds are free from cracks, inclusions and cavities. In the case of pipes or branch pieces of alloy steel mechanical tests and tests to destruction may also be required to demonstrate that the joints are of adequate strength. Check tests are to be carried out periodically at the Surveyor's discretion.

518 All welds attaching flanges and branches to alloy steel pipes of 3 inches bore and over are to be examined to ensure as far as possible that the welds are satisfactory. These examinations are to be carried out by radiography where practicable or by other approved methods. Defects, if found, are to be cut out and the seam rewelded and re-examined.

Heat Treatment of Steel Pipes and Branch Pieces

519 Carbon steel pipes intended either for pressures above 150 lb. per square inch or temperatures above 500° F. are to be stress relieved where they have been heated for bending the pipe or for any other purpose and where the flanges have been attached by metal arc welding. Where oxy-acetylene welding has been employed, the pipes are to be normalised.

All alloy steel pipes and fabricated branch pieces are to be carefully and suitably heat treated under accurate temperature control after cold or hot bending, welding or other hot work. Stress relieving or normalising may be used after metal arc welding, and normalising

is required after bending and oxy-acetylene welding. Other methods of heat treatment will be considered on submission of full details.

Suitable temperatures for heat treatment are given in Table 4 and should be maintained for one hour per inch of wall thickness.

TABLE 4

Pipe steel	Temperature limits for	
	Stress Relieving	Normalising
Carbon	1110–1200°F. 600– 650°C.	1700–1760°F. 927– 960°C.
½% Mo. ½% Cr., ½% Mo. 1% Cr., ½% Mo.	1150–1225°F. 620– 663°C.	1700–1760°F. 927– 960°C.
2¼% Cr., 1% Mo.	1200–1255°F. 650– 680°C.	1740–1780°F. 950– 970°C.
½% Mo., ¼% V.	1185–1240°F. 640– 670°C.	1740–1780°F. 950– 970°C.

Hydraulic Test Pressures

520 All main steam and feed pipes are, on completion, to be tested by hydraulic pressure to not less than twice the working pressure as defined in 506 and 512. Other pipes are to be similarly tested when intended for working pressures above 150 lb. per square inch.

In the case of superheat steam pipes and fabricated branch pieces a test pressure (TP) is to be applied so that these parts are subjected, under hydraulic test, to approximately the same wall stress as saturated steam pipes. The hydraulic test pressure is to be as follows, but need not be more than 4,500 lb. per square inch.

$$TP = 2\,WP \times \frac{f \text{ at } 650^\circ \text{ F.}}{f \text{ at working temperature}}$$

Where f is obtained from Table 1.

If the individual pipes are assembled and the joints butt welded in place, an additional hydraulic test of 2WP is to be applied to the erected pipe line.

For the testing of the completed oil fuel pipes and heating coil systems after fitting on board *see* E 310, E 312 and E 335.

Cast Iron Heating Pipes

521 Where it is desired to use pressure pipes of cast iron, details are to be submitted.

Section 6

STEAM PIPE RANGES

Provision for Expansion

601 In all steam pipe ranges provision is to be made for expansion and contraction to take place without unduly straining the pipes.

Where corrugated pipes are used, particulars are to be submitted.

Drainage

602 The slope of the pipes and the number and position of the drain cocks or valves are to be such that water can be efficiently drained from any portion of the steam pipe range when the ship is in normal trim and is either upright or has a list up to 5 degrees.

Arrangements are to be made for ready access to the drain cocks or valves.

Pipes in way of Holds

603 Pipes conveying steam are not to be led through spaces which may be used for cargo, except with the approval of the Committee.

If these pipes are led through shaft tunnels, pipe tunnels in way of cargo holds or through duct keels, they are to be efficiently secured and insulated.

Reduced Pressure Lines

604 Pipe lines which are situated on the low pressure side of reducing valves and which are not designed to withstand the full pressure at the source of supply are to be fitted with pressure gauges and with relief valves having sufficient discharge capacity to protect the piping against excessive pressure.

Valves and Fittings

605 Valves and fittings intended either for steam pressures above 150 lb. per square inch or temperatures above 425° F. are to be of steel, carbon or low alloy, or other approved material suitable for the working temperature.

Castings of bronze, iron and carbon steel may be used within the following limits of temperature and pressure:—

Bronze	425° F. 150lb. per square inch
Iron	450° F. 150lb. per square inch
Carbon Steel	850° F. all pressures.

Hydraulic Test Pressure

606 All main steam and feed valves and fittings are to be tested by hydraulic pressure to not less than twice the working pressure as defined in E 506 and E 512. Other valves and fittings are to be similarly tested when intended for working pressures above 150 lb. per square inch.

For the testing of boiler mountings *see* J 302 and J 1510.

Steam for Fire Extinguishing in Cargo Holds

607 Where steam is used for fire extinguishing in cargo holds, provision is to be made to prevent damage to cargo by leakage of steam or by drip.

Details of the proposed precautionary measures are to be submitted.

Section 7

BOILER FEED WATER SYSTEMS

Feed Pumps

701 Two separate means of feed are to be provided for all main, auxiliary and donkey boilers which are required for essential services, with the exception of boilers in which steam is generated exclusively by exhaust gases or steam, where one means of feed will be accepted provided an alternative steam supply is available.

702 Two or more feed pumps are to be provided of sufficient capacity to supply the boilers under full load conditions with any one pump out of action.

703 Feed pumps may be worked from the main engines or may be independently driven but at least one of the pumps required in 702 is to be independently driven.

704 In twin screw ships in which there is only one independent feed pump each main engine is to be fitted with a feed pump. Where all the feed pumps are independently driven, the pumps are to be connected to deal with the condensate from both engines or from either engine.

705 Independent feed pumps required for feeding the main boilers are to be fitted with automatic regulators for controlling their output.

706 Where main-engine driven feed pumps are fitted and there is only one independent feed pump, a harbour feed pump or an injector is to be fitted to provide the second means of feed to the boilers which are in use when the main engines are not working.

707 Feed pumps are to be provided with valves or cocks interposed between the pumps and the suction and the discharge pipes so that any pump may be opened up for overhaul while the others continue in operation.

Sea Suction

708 One of the independent feed pumps is to be provided with an emergency suction to the sea, except in the cases mentioned in 709.

Suctions are also to be provided from this pump to the hotwell or condenser, unless suitable stand-by connections have already been provided for this purpose.

709 The sea suction to a feed pump may be omitted if large reserve feed tanks are provided and an evaporator of adequate capacity is fitted.

Reserve Feed Water

710 All ships fitted with boilers are to be provided with storage space for reserve feed water, the structural and piping arrangements being such that this water cannot be contaminated by oil or oily water.

General Service Pump

711 An auxiliary independent feed pump may be used for general service, provided it is not connected to tanks containing oil fuel or cargo oil or to tanks, cofferdams and bilges containing oily water.

The valves on the suction pipes from the hotwell or condenser and the feed drain tank or filter are to be of non-return type.

Filters

712 Where superheated steam is used in main or auxiliary engines of reciprocating type, filters are to be fitted to provide for the continuous filtration of the boiler feed water.

713 Where a direct contact heater is supplied with exhaust steam from engines of reciprocating type, the feed water from the heater is to be led through the filters required by 712 or through additional filters arranged to provide for continuous filtration.

Cross-references

714 For materials, working pressure and test pressure of feed pipes, *see* E 501 to E 520.

For feed water level regulators for water tube boilers, *see* J 1708.

Section 8

ENGINE COOLING WATER SYSTEMS

Main Supply

801 Provision is to be made for an adequate supply of cooling water to the main propelling machinery and essential auxiliary engines, also to the lubricating oil and fresh water coolers and air coolers for electric propelling machinery where these coolers are fitted. The cooling water pump(s) may be worked from the engines or be driven independently.

Alternative Supply

802 Provision is also to be made for a separate emergency supply of cooling water from a suitable pump.

Sea Inlets

803 Not less than two sea inlets are to be provided for the pumps supplying the salt water cooling system, one for the main pump and one for the stand-by pump. Alternatively, the sea inlets may be connected to a suction line available to main and stand-by pumps.

These inlets are to be low inlets and one of them may be the ballast pump or general service pump sea inlet.

Stand-by Fresh Water Pump

804 Where fresh water cooling is employed, a stand-by fresh water pump need not be fitted if there be suitable emergency connections from a salt water system.

Cooling Water Supply to Auxiliaries

805 Where each auxiliary is fitted with a cooling water pump, stand-by means of cooling need not be provided. Where, however, a group of auxiliaries is supplied with cooling water from a common system, a stand-by cooling water pump is to be provided for this system. This pump may be a suitable general service pump.

Strainers

806 Where sea water is used for the direct cooling of the main engines and essential auxiliary engines, the cooling water suction pipes are to be provided with strainers which can be cleaned without interruption to the cooling water supply.

Relief Valves

807 Cooling water pumps worked from the main engines are to be provided with relief valves on the pump discharge.

Section 9

LUBRICATING OIL SYSTEMS

Pumps

901 In ships of unrestricted class in which the lubricating oil for the main engines is circulated under pressure and the total power exceeds 400 i.h.p. in the case of steam reciprocating engines and 350 s.h.p. in the case of turbines, internal combustion engines and electric propelling machinery two or more lubricating oil pumps are to be fitted and connected ready for immediate use.

The pumps are to be of sufficient capacity to maintain the supply of oil for normal conditions with any one pump out of action.

Similar provision is to be made where separate lubricating oil systems are employed for the operation of reverse reduction gears and oil operated couplings.

Emergency Supply for Main Turbines and Main Turbo-Generators

902 A suitable emergency supply of lubricating oil is to be provided. This may be effected by arranging for an automatic gravity supply of lubricating oil sufficient to maintain adequate lubrication for not less than 3 minutes, and in the case of turbo-generators until the unloaded turbine comes to rest from its maximum rated running speed.

An alarm device is also to be arranged to give audible warning in the event of the failure of, or an appreciable reduction in, the supply of lubricating oil from the pump.

Strainers

903 Where the lubricating oil for the main propelling engines and for the generator engines in electrically propelled ships is circulated under pressure, provision is to be made for efficiently straining the lubricating oil.

904 The strainers or filters are to be capable of being cleaned without stopping the oil supply to the engine.

905 Where strainers are fitted on the discharge side of the lubricating oil pump, a relief valve in close circuit is to be fitted between the pump and the strainer.

Drip Trays

906 In ships built of wood, easily drained metal or metal-lined trays are to be fitted to prevent saturation of the woodwork by leakage from the engine and its filters.

Lubrication of Bearings

907 The arrangements for lubricating bearings and for draining crankcase and other oil sumps of main and auxiliary engines, gear cases, electric generators, motors and other running machinery are to be so designed that lubrication will remain efficient with the ship inclined from the normal at any angle up to 15 degrees transversely and when pitching 10 degrees longitudinally and when rolling up to 22½ degrees from the vertical.

908 For details of the requirements relating to the lubrication of bearings of electric generators and motors, *see* M 107.

Valves and Cocks

909 Outlet valves and cocks on lubricating oil service tanks, other than double bottom tanks, situated in machinery spaces are to be capable of being closed locally and from positions outside the compartment which will always be accessible in the event of fire occurring in these spaces. Remote controls need only be fitted to outlet valves and cocks which are open in normal service and are not required for other outlets such as those on storage tanks. Indicators are to be provided at the valves and cocks and at the remote control positions to show whether they are open or closed.

In the case of very small tanks consideration will be given to the omisson of remote controls.

Cross-references

910 For air and sounding pipes and gauge glasses, *see* E 404, E 413 and E 415.

Section 10

PUMPING ARRANGEMENTS FOR SHIPS NOT FITTED WITH PROPELLING MACHINERY

Hand Pumps

1001 Where auxiliary power is not provided, hand pumps are to be fitted in number and position as may be required for the efficient drainage of the ship.

The pumps are to be capable of being worked from the upper deck or from positions above the load water line which are at all times readily accessible.

The suction lift is not to exceed 24 feet, and is to be well within the capacity of the pump.

1002 The sizes of the hand pumps are not to be less than given in the following table:

Tonnage under Upper Deck	Hand Pumps	
	Diameter of barrel of bucket pump inches	Bore of Suction pipe of bucket pumps and semi-rotary pumps inches
Not exceeding 500 tons ...	4	2
Above 500 tons but not exceeding 1,000 tons ...	4½	2¼
Above 1,000 tons but not exceeding 2,000 tons ...	5	2½
Above 2,000 tons	5½	2¾

Where the ship is closely subdivided into small watertight compartments 2 inches bore suctions will be accepted.

Power Pumps

1003 In ships in which auxiliary power is available on board, power pump suctions are to be provided for dealing with the drainage of tanks and of the bilges of the principal compartments.

The pumping arrangements are to be as required for self-propelled ships in so far as these requirements are applicable, duly modified to suit the size and service of the ship.

Details of the pumping arrangements are to be submitted for special consideration.

Fire Extinguishing

1004 Wherever practicable, a power pump or hand pump is to be fitted having a suction from the sea and a discharge to deck for fire extinguishing purposes.

Where oil fuel is used for the generation of power, details of the fire extinguishing appliances are to be submitted.

Section 11

PETROLEUM AND OTHER LIQUID CARGOES HAVING A FLASH POINT BELOW 150° F.

General

1101 The following requirements are based on the assumption that the ships are of normal tanker type having the main propelling machinery aft.

Departures from normal type will require special consideration.

Cargo Oil System

1102 A complete system of piping and pumps is to be fitted for dealing with the cargo oil.

1103 Cargo pump rooms are to be enclosed by oiltight bulkheads and are to have no direct communication with machinery spaces.

1104 Pumps for the purpose of filling or emptying the cargo oil tanks are to be used exclusively for this purpose, except as provided in 1107. They are not to have any connections to compartments outside the range of cargo oil tanks.

Cargo oil pumps are to be capable of being controlled from outside the pump rooms, as well as at the pumps.

1105 The pumps are to be provided with effective escape valves which are to be in close circuit, i.e., discharging to the suction side of the pumps.

1106 Expansion joints or bends are to be provided where necessary in the cargo pipe lines.

1107 Provision is to be made for the bilge drainage of the cargo pump rooms by pump or bilge ejector suctions. The cargo pumps or cargo stripping pumps may be used for this purpose, provided the bilge suctions are fitted with screw-down non-return valves and, in addition, an isolating valve or cock be fitted on the pump connection to the bilge chest. The pump room bilges of small tankers may be drained by means of a hand pump having a 2 inches bore suction.

Pump room suctions are not to enter machinery spaces.

1108 Pump rooms are to be provided with ready means of access and adequate ventilation.

1109 Ullage plugs or sighting ports are to be provided at each tank to enable the amount of ullage to be ascertained.

Ullage plugs or sighting ports should not be fitted in any enclosed space.

1110 Provision is to be made for the gas freeing of the cargo oil tanks when the cargo has been discharged and for the ventilation and gas freeing of all compartments adjacent to cargo oil tanks.

1111 Vapour pipes are to be fitted to cargo oil tanks and connected through shut-off cocks or valves or pressure-vacuum valves to a vapour line led up the mast or other post to a safe height above the weather deck. The outlets from these vapour mains are to be provided with readily renewable wire gauze or safety heads of approved types. If alternative means of dealing with the vapour are desired, details are to be submitted.

Bilge, Ballast, Oil Fuel and other Piping not within the Cargo Oil System

1112 The pumping arrangements in the machinery space and at the forward end of the ship are to comply with the requirements for general cargo ships in so far as they are applicable and with the special requirements detailed in 1113 to 1117.

1113 A separate power pump is to be fitted in a suitable compartment forward of the cargo tanks to deal with bilge drainage, water ballast and oil fuel pumping at the fore end of the ship.

In small tankers, a forward power pump may be dispensed with, provided suitable alternative arrangements are made, details of which are to be submitted.

1114 Where deep cofferdams can be filled with water ballast, a ballast pump in the main engine room may be used for emptying the after cofferdam, provided the suction be led direct to the pump and not to an engine room pipe system. The ballast pump in the forward pump room may be used for emptying the forward cofferdam.

1115 Cofferdams are not to have any direct connections to the cargo oil tanks or cargo oil lines.

Where intended to be dry compartments, after cofferdams adjacent to the pump room may be drained by a cargo pump, provided isolating arrangements are fitted in the bilge system as required by 1107; forward cofferdams may be drained by the bilge and ballast pump in the forward pump room. Alternatively, cofferdams may be drained by hand pumps or bilge ejectors.

Cofferdams are to be provided with sounding pipes and with air pipes led to the open. These air pipes are to be fitted with wire gauze diaphragms at their outlets.

1116 Bilge, ballast, oil fuel and other piping connected to the pumps at the ends of the ship are not to pass through the cargo oil tanks or have any connection with these tanks.

Cargo oil pipes are not to pass through ballast or oil fuel tanks or through compartments which are external to the cargo oil system.

1117 The oil fuel bunkering system is to be entirely separate from the cargo oil system.

Steam and Exhaust Piping

1118 Where heating coils are provided in the cargo oil tanks they are to be made and fitted under the usual conditions of survey and testing. (*See* E 334 to E 336, E521 and E 601 to E 607.)

An observation tank is to be provided for the heating coil drains and is to be situated in a well ventilated and well lighted part of the machinery space remote from the boilers.

Spectacle flanges are to be provided in the main steam and exhaust pipes to the cargo oil heating system, at a suitable position forward of the machinery space bulkhead, so that the lines can be blanked off in circumstances where cargo oil does not require to be heated or where heating coils are not fitted in the tanks.

1119 Steaming out and fire extinguishing connections for cargo oil tanks or cargo oil pipe lines are to be fitted with valves of non-return type and the main supply to these connections is to be fitted with a master valve placed in a readily accessible position clear of the tanks.

1120 In the cargo pump rooms, drain pipes from steam or exhaust pipes or from the steam cylinders of the pumps are to terminate well above the level of the bilges.

Motive Power of Cargo Oil Pumps

1121 Where the cargo oil pumps are not driven by steam, plans of the arrangements for driving the pumps are to be submitted.

1122 Where cargo pumps are driven by shafting which passes through a pump room bulkhead or deck, gastight glands with efficient means of lubrication are to be fitted to the shaft at the pump room plating.

Auxiliary Machinery outside Main Engine Room

1123 Internal combustion engines are not to be situated within pump rooms, cofferdams or other spaces liable to contain petroleum or other explosive vapours.

(For requirements for electrical equipment within such spaces, *see* M 16.)

Fire Extinguishing Arrangements

1124 The cargo pump rooms are to be provided with a deck operated fire extinguishing system using steam, CO_2 or other suitable medium.

In addition, two portable foam extinguishers are to be provided, one at the pumps and one at the pump room entrance.

20th July, 1961.

Chapter F

FIRE EXTINGUISHING ARRANGEMENTS in machinery spaces and cargo oil pump rooms (including deck fire main).

Section 1

WATER SERVICE AND FIRE PUMPS

Fire Main and its Connections

101 In all ships provision is to be made for pumping water for fire extinguishing service.

102 The fire main is not to be of cast iron, and if made of iron or steel is to be galvanised. It is to be protected from mechanical damage and is not to be led through cargo spaces, if it is practicable to avoid doing so. The wash deck line may be used as a fire main, provided it complies with the requirements of this Section.

103 A relief valve is to be fitted in the engine room on the discharge line from the fire pumps to prevent any excessive pressure arising in the fire main.

The relief valve may be omitted where the maximum pump discharge pressure cannot greatly exceed the jet operating pressure.

104 The sizes of the fire main and of its connections and fittings are to be sufficient to supply in simultaneous operation the fire hoses required by 107. Where the machinery is fitted amidships, the discharge line from the pumps to the fire main is to be led through a change cock (with permanently attached handle) or through two isolating valves so arranged that the hydrants at both ends of the ship may be used either simultaneously or separately.

105 The hose nozzles used for extinguishing fires other than oil fires, are to have a minimum bore of $\frac{1}{2}$ inch.

106 Hydrants are to be provided with shut-off cocks or valves. They are to be arranged so that any part of the ship may be reached by a jet of water about 40 feet in length through a single length of hose, and so that they will be accessible when deck cargo is carried.

Number of Jets of Water

107 The number of jets of water, required to be about 40 feet in length, is to be as follows:—

In ships of less than 1,000 tons gross ...	1 jet
In ships of 1,000 tons gross and over ...	2 jets

Hoses are to be provided so that the required jet can be directed to any part of the ship. Where two jets are required these are to be capable of simultaneous operation.

108 All ships of 1,000 tons gross and over which use oil as fuel, are to be provided with two fire hydrants in the machinery spaces, one port and one starboard, complete with hoses having nozzles suitable for spraying water on oil. In ships less than 1,000 tons gross one such hydrant is to be provided.

The hoses are to be of sufficient lengths to permit an effective spray of water to reach any part of the engine or boiler rooms which contain oil fuel tanks or appliances.

Fire Pumps

109 In ships less than 150 tons gross, one power pump is to be available for fire extinguishing service. If the ship has a restricted class for harbour or river service a suitable hand pump may be substituted for the power pump.

110 In ships of 150 tons gross and over, but less than 1,000 tons gross, not less than two power pumps are to be provided, one of which is to be an independent pump.

111 In ships of 1,000 tons gross and over, not less than two independent power pumps are to be provided.

112 Fire pumps may be engine room general service pumps or ballast pumps, provided they are arranged to prevent oil being discharged accidentally into the fire extinguishing system.

113 Each fire pump is to be capable of maintaining, at the hose nozzles, the 40 foot jets of water required by 107.

114 If in ships of 1,000 tons gross and over, which burn oil as fuel, a fire in any one compartment could put all the fire pumps out of action, alternative means for extinguishing the fire are to be provided either by emergency fire pumps driven by compression ignition oil engines, or by other approved fire extinguishing system.

FIRE EXTINGUISHING EQUIPMENT IN MACHINERY SPACES OF OIL BURNING STEAMSHIPS AND MOTORSHIPS

Section 2

General Requirements

201 The machinery spaces are to be provided with the fire hydrants and hoses required by F 108.

202 Provision is to be made for stopping from positions outside the machinery spaces, ventilating fans for these compartments, also other fans or blowers situated within the compartments, and for closing as far as practicable all openings to the machinery spaces.

The engine room skylights are to be capable of being shut from deck or from a safe position outside the machinery space.

Cross-references

203 For other precautionary arrangements relating to oil leakage and outbreaks of fire see:—

D 2024–2025, D 2027, and E 310, E 315–319, E 330–333, E 337–343, E 403–405, E 407, E 413–414.

Section 3

Oil Burning Steamships

301 There is to be provided at each firing platform:—

(*a*) A bin containing not less than 10 cubic feet of sand, sawdust impregnated with soda, or other dry material suitable for extinguishing oil fires. Scoops are to be provided at each bin.

(*b*) Not less than two portable fire extinguishers.

302 In addition, a froth extinguisher of 10 gallons capacity, or equivalent, is to be provided in each boiler room in which the number of burners exceeds four. Where the number of burners in a boiler room is four or less, the 10 gallon extinguisher may be replaced by one portable fire extinguisher of 2 gallons capacity, or its equivalent, for each burner.

The number and position of the portable extinguishers are to be such that not less than two extinguishers are situated within any compartment containing settling tanks or the whole or part of the oil fuel installation.

303 In boiler rooms and in any space in which oil fuel units or settling tanks are situated, a fire extinguishing apparatus is to be provided which can be controlled from outside these compartments, at positions which are easily accessible and which would not readily be cut off by an outbreak of fire in any of the above-mentioned compartments. If the engine and boiler rooms are not entirely separate and oil fuel can drain from one compartment to the other, these spaces shall be considered as one compartment.

The apparatus is to be capable of discharging rapidly, through a permanent piping system, a fire extinguishing medium which is to be either froth, CO_2 or steam.

Froth Apparatus

304 The froth apparatus is to be capable of discharging froth to a depth of 6 inches over the largest area on which oil fuel is liable to spread in the event of a leakage of oil fuel.

Where the boilers are situated in an upper part of the machinery space, the above requirement applies also to the flat on which the boilers are situated.

305 Where the upper parts of the machinery spaces contain oil fuel tanks and appliances, additional fire protection is to be provided by fitting a froth extinguisher of 10 gallons capacity, or a CO_2 extinguisher of 35 lb. capacity, having a hose on reel capable of reaching any surface of the upper machinery space on which escaping oil would be liable to fall.

CO_2 Apparatus

306 The CO_2 fire extinguishing apparatus is to be capable of discharging gas in sufficient quantity to give a minimum volume of free CO_2 equal to 30 per cent of the gross volume of the largest space measured to the top of the boilers. The volume of the gas is to be taken as 9 cubic feet per pound of liquefied CO_2.

If the upper parts of the machinery spaces contain oil fuel tanks and appliances, it will be necessary to supply, in addition, the 10 gallon froth extinguisher or the 35 lb. CO_2 extinguisher required by 305.

307 If the CO_2 is supplied in sufficient quantity to give a minimum volume of free CO_2 equal to 30 per cent of the gross volume of the largest space measured to the top of the casing of the compartment and the gas is discharged into the upper part of the space as well as into the lower part, the 10 gallon froth extinguisher or the 35 lb. CO_2 extinguisher required by 306 need not be provided.

308 Where CO_2 is used as the fire extinguishing medium in cargo holds as well as in machinery spaces, the total quantity of CO_2 need not exceed that required for the largest compartment protected in this way, whether cargo or machinery space.

309 The CO_2 fire extinguishing system is to be provided with an automatic audible alarm to operate when the CO_2 is about to be injected into the machinery space

or other working space. The arrangement of controls for the CO_2 apparatus is to be such that the apparatus may be operated only at the control station(s).

Steam Apparatus

310 Where steam is used as the fire extinguishing medium, it is to be led to pipes perforated for the emission of steam into the lower parts of the compartments. Where the boilers are situated in an upper part of the machinery space, the above requirement applies also to the flat on which the boilers are situated.

Steam for the apparatus is to be available in sufficient quantity from all boilers.

The perforated pipes are to be fitted not less than 6 inches above the tank top and bilges to avoid immersion in an accumulation of bilge water. If the pipes are of steel they are to be galvanised internally and externally. They are to be arranged to be self-draining. If the steam for the fire extinguishing system is obtained exclusively from water tube boiler(s), a 30 gallon froth extinguisher or a 100 lb. CO_2 extinguisher is also to be provided.

Steam used for fire extinguishing purposes is not to be obtained from a supply of superheated steam.

Steamships having Auxiliary Oil Engines

311 In oil burning steamships where oil engines are installed as the main source of auxiliary power, two portable extinguishers additional to the above requirements are to be provided ; otherwise, no additional equipment will be required.

In coal burning steamships fitted with auxiliary oil engines the fire extinguishing arrangements are to be submitted for consideration.

Section 4

Motorships not fitted with Boilers

401 The following extinguishers are to be provided in the machinery space:—

B.H.P. of Main Engines in one Engine Room	Number of Extinguishers	
	Portable	10 gallon capacity or equivalent
Not exceeding 500	2	—
501 to 1,000 inclusive	2	1
1,001 to 2,000 ,, ...	3	2
2,001 to 3,000 ,, ...	4	2
3,001 to 4,000 ,, ...	5	2
Exceeding 4,000	6	2

The number and position of the extinguishers are, however, to be such that not less than two extinguishers are to be provided in each machinery space containing oil fuel tanks or appliances.

402 In motorships having more than one engine room, the requirements of 401 are to be applied to each engine room.

If a separate engine room is provided for auxiliary oil engines, the b.h.p. is to be taken as the total power of these engines.

Motorships Fitted with Oil Fired Boilers

403 In addition to the requirements of 401 and 402, the requirements of Section 3 are to be complied with so far as they are applicable, but the total number of 10 gallon extinguishers need not exceed two in any one machinery space.

In motorships in which the oil fired boiler installation consists of a vertical boiler situated in the open engine room, the externally controlled fire extinguishing apparatus required by F303, may be replaced by a froth extinguisher capable of providing not less than 6 inches of froth over the entire area of the oiltight tray or flat situated under the boiler. This tray is to be of adequate dimensions to ensure the collection of any escaping oil in the vicinity of the boiler.

Section 5

FIRE EXTINGUISHERS

501 The extinguishers required for use in the machinery spaces of ships burning oil as fuel are to be of a type discharging froth, CO_2 or other approved medium suitable for extinguishing oil fires.

Portable extinguishers are to have a minimum capacity of 2 gallons or equivalent and a maximum capacity of 3 gallons or equivalent.

The extinguisher capacities mentioned in these Rules refer to the quantity of fluid contained in the extinguishers.

502 Portable extinguishers are to be fitted in readily accessible positions and a notice plate is to be provided stating that on no account are discharged extinguishers to be replaced in their holders until they have been replenished.

One extinguisher is to be fitted in the vicinity of the entrance door to the space in which it is intended to be used.

503 A spare charge is to be provided for each portable fire extinguisher which can be readily re-charged on board. If this cannot be done, duplicate extinguishers are to be provided.

504 The makers of portable and fixed fire extinguishing appliances are to furnish a certificate stating the nature and quantity of the fire extinguishing medium. In the case of fixed froth or gas fire extinguishing systems the makers are to state whether the quantity supplied is adequate to give the required depth of froth or gas concentration.

If considered necessary, the Committee may require the makers to produce evidence from a recognised independent testing authority regarding the suitability of their appliances.

Acceptable Equivalents

505

30 gal. froth extinguisher	–	100 lb. CO_2	extinguisher
10 gal. froth „	–	35 lb. CO_2	„
Portable froth „	–	10 lb. CO_2	„

14th March, 1957.

Cross-reference

506 For Fire Extinguishing requirements for pump rooms of Petroleum Tankers *see* E 1124.

Section 6

EQUIVALENT ARRANGEMENTS

601 Arrangements and appliances which differ from those mentioned in the foregoing requirements may be accepted, provided full details are submitted, as early as practicable, for the consideration of the Committee and are found to be equivalent to the Society's requirements.

Alternative Arrangements

602 Where fire extinguishing arrangements and equipment are controlled by the law of the country in which the ship is registered then the relevant statutory requirements may be accepted as alternatives to the requirements of this section.

Chapter G

CONDITIONS FOR SURVEY OF MACHINERY DURING CONSTRUCTION

Section 1

101 The materials used in the construction of the machinery, boilers and pressure vessels are to comply with the requirements of Chapter P. Materials, for which provision is not made in Chapter P, may be accepted after compliance with such tests as may be imposed, under specifications to be approved before the materials are ordered and construction is commenced.

The machinery, boilers and pressure vessels are to be inspected throughout, the boilers and pressure vessels tested by hydraulic pressure, and the machinery tested under full power working conditions by the Society's Engineer Surveyors, who will furnish a report to the Committee. If found satisfactory, the Committee will thereupon grant a certificate, and insert in the Register Book the appropriate class notation, as set forth in Chapter B, indicating that the machinery, boilers and pressure vessels are certified to have been in good order and safe working condition on that date.

102 In cases of machinery which has been built under Special Survey, the distinguishing mark ✠ will be inserted before the appropriate class notation, as set forth in Chapter B.

103 In ships built under Special Survey, the following items of machinery are also to be constructed under Special Survey:—

The main and auxiliary engines and boilers, superheaters, economisers (including press boilers and similar apparatus for floating whale-oil factories), steering engines, air receivers, air compressors, scavenge blowers and superchargers, oil fuel burning units, feed pumps, circulating and cooling water pumps, fire and bilge pumps, air pumps, ballast and oil fuel transfer pumps, water extraction pumps, lubricating oil pumps, fuel valve cooling pumps for heavy oil engines, forced and induced draught fans, evaporators, distiller units, feed water heaters and pressure filters where the foregoing are intended for essential services and domestic boilers intended for working pressures exceeding 50 lb. per square inch and having heating surfaces greater than 50 square feet.

Generators of 100 kW or 100 kVA and over and motors of 100 h.p. or 100 kVA and over intended for essential services.

Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces.

Electric slip couplings.

All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motors and exciters.

104 In order to facilitate the inspection, plans in triplicate of the following items, together with the necessary particulars of the machinery, including the maximum power and the revolutions per minute, are to be submitted for consideration before the work is commenced:—

Boilers, superheaters and economisers.

Air receivers.

Crank, thrust, intermediate and screw shafting and screw shaft oil gland.

Clutch, reversing gear with methods of control and flexible coupling.

Reduction gearing. (*See also* H 503.)

Propeller (including spare propeller if supplied).

General arrangement of shafting showing relative positions of the main engines, flywheel, flexible coupling, gearing, thrust block, line shafting and bearings, stern tube, "A" bracket and propeller, whichever are applicable.

NOTES—Plans additional to the above should not be submitted unless the machinery is of a novel or special character affecting classification.

For Plans of Pumping and Piping required to be submitted, *see* E 101.

For Welded Structures for Steam Reciprocating and Heavy Oil Engines, *see* H 902.

For Welded Pressure Vessels, *see* J 1806.

For Electrical Equipment and Electric Propelling Machinery, *see* M 102.

For Refrigerated Cargo Installations, *see* N 202.

105 Where it is proposed to depart from the requirements of the Rules, the Committee will be prepared to give consideration to the circumstances of any special case.

106 Any novelty in the construction of the machinery, boilers or pressure vessels is to be reported to the Committee.

107 The Surveyors are to examine the materials and workmanship from the commencement of the work until the final test of the machinery under full power working conditions; any defects, etc., are to be pointed out as early as possible.

108 The Surveyors may also, if requested, compare the work as it progresses with the requirements of the specification agreed upon by the parties concerned, and certify to the conditions thereof, as far as can be seen, being satisfactorily complied with.

109 The machinery and boilers are to be securely fixed to the ship's structure to the satisfaction of the Surveyor. The bed plates, gear cases, thrust blocks and boiler fastenings are to be of robust construction.

110 Refrigerating machinery using a toxic or inflammable refrigerant, such as ammonia, is to be installed in an efficiently ventilated compartment isolated from the propelling machinery spaces and shaft tunnels, and living quarters.

Methyl chloride refrigerant is not to be used.

Machinery using non-toxic and non-inflammable refrigerants will not be subject to restriction on location in general, but proposals to install relatively large plants in propelling machinery spaces will require special consideration.

Cross-references

111 For conditions relating to the survey during construction of Electrical Equipment, Electric Propelling Machinery and Refrigerating Machinery and Appliances, *see* M 1, M 17 and N 1 respectively.

20th July, 1961

Chapter H

STEAM ENGINES, INTERNAL COMBUSTION ENGINES, REDUCTION GEARING AND AUXILIARY MACHINERY, STRENGTHENING FOR NAVIGATION IN ICE

Section 1

GENERAL REQUIREMENTS FOR SHAFTING

Materials for Shafts

101 Shafts may be forged from ingot steel, wrought iron bars piled, or scrap wrought iron, and they may be wrought by hammer, press, or where in straight lengths, by rolling mill.

102 If scrap is used it must be of uniform quality and be thoroughly cleansed. A mixture of iron and steel scrap is not permitted in any case.

103 Where ingot steel is used for shafts it is to comply generally with the requirements of P 6.

104 Where ingot steel shafts are made by rolling and the couplings are formed from the shafts by upsetting, the test pieces may be cut from the outer edges of the couplings.

Materials for Couplings

105 Couplings of wrought iron shafts may be welded to the body of the shaft, but those of ingot steel shafts are to be forged from the solid or by upsetting the ends by hydraulic pressure.

106 Couplings, where separate from the shaft, may be forged from ingot steel or wrought iron; or they may be steel castings.

Materials for Crank Shaft Webs

107 Webs of built crank shafts may be forged or rolled from ingot steel or wrought iron; or they may be steel castings.

108 The material of rolled or forged steel webs is to comply with the requirements of P 6. The test pieces are to be taken crosswise from the webs as rolled or forged.

109 The material of cast steel webs is to comply with the requirements of P 5.

Inspection

110 All shafts are to be turned all over and are to be examined when rough turned and when finished.

Alignment Gauges

111 All main and auxiliary heavy oil engines exceeding 300 b.h.p. and all main steam reciprocating engines are to be provided with alignment gauges which may be either a bridge gauge or a micrometer clock gauge for use between the crank webs.

Only one micrometer clock gauge, suitable for all the engines, need be supplied for each ship.

Main and auxiliary steam turbines are to be provided with gauges of an approved type for testing the alignment of the rotor, pinion and gear wheel shafts.

Wear down gauges and turbine alignment gauges should be adjusted in the presence of the Surveyor.

Section 2

STEAM RECIPROCATING ENGINES

Dimensions of Shafts

201 The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28–32 tons per square inch, are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of severe torsional vibration stresses arising in the shafting. Where engines have cylinders of uniform diameter and in other types of engines where experience indicates that serious critical speeds might occur within or near the range of working speeds, calculations of the torsional vibration characteristics, including 1-node natural frequency tables, for the complete shafting system, are to be submitted for consideration together with plans of all shafting and of the propeller.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

These calculations are not required to be submitted for engines other than these special cases; they may, however, be submitted voluntarily, if desired.

The Committee will accept intermediate shafts with a diameter 5 per cent less than required by the Rule formulæ, in all cases where calculations confirm that the shafting systems are free from excessive vibration stress or would be satisfactory with a barred speed range.

This 5 per cent reduction in diameter will be limited to the intermediate shafts only and will not be applicable to the sizes of couplings and their bolts.

Where serious critical speeds are found by calculation to occur within the range of working speeds, the Committee may require torsicgraph records to be taken from the machinery, for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

202 Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Intermediate Shaft

203 The diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\text{Diameter of intermediate shaft, in inches} = \sqrt[3]{\frac{D^2 \times S \times WP}{C\left(\frac{D^2}{H^2} + 2\right)}}$$

where WP = working pressure at the boiler outlet, in lb. per square inch.

NOTE.—The working pressure at the boiler outlet is the pressure as controlled by boiler or superheater safety valves and as defined in E 512.

D = diameter of the low pressure cylinder, in inches, or the equivalent diameter where two or more low pressure cylinders are fitted,

H = diameter of the high pressure cylinder, in inches,

S = length of stroke, in inches.

C is a coefficient given in the following Table:—

Compound, triple or quadruple expansion reciprocating engines	Values of C
2 cranks at 90°	1900
2 cranks at 180°	1350
3 cranks at 120°	2150
4 cranks balanced	2150
4 cranks at 90°	2100

Note: The rule diameter of the intermediate shaft may be reduced by 3·5 per cent for ships classed exclusively for smooth water service and by 1·75 per cent for ships classed exclusively for service on the Great Lakes.

For the diameter of the intermediate shafting of steam reciprocating engines combined with exhaust steam turbines, *see* H 304.

Crank Shaft

204 The diameter of the crank shaft is not to be less than 1·05 times that required for the intermediate shaft as determined by 203.

Crank Webs of Solid Forged Shafts

205 In solid forged shafts the breadth of the webs should not be less than 1·33 times and the thickness not less than ·56 times the diameter required for the crank shaft or, if these proportions are departed from, the webs are to be of equivalent strength.

Crank Webs of Built Shafts

206 The dimensions of the crank webs of built shafts should not be less than those given by the following formulæ:—

$$h = \cdot 625 \times d$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in inches or millimetres,

t = thickness of metal around the eyeholes, measured radially, in inches or millimetres,

d = diameter required for the crank shaft, in inches or millimetres.

If these proportions are departed from, the webs are to be of equivalent strength.

207 Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

Shrinkage Allowance

208 Crank webs are to be securely shrunk on the journals and crank pins. If dowels are not fitted at the junction of the journals and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch, and the shrinkage allowance is to be between $\frac{1}{350}$ and $\frac{1}{700}$ of the diameter of the shaft.

Fillets and Oil Holes

209 Fillets at the junctions of crank webs with crank pins or journals, where these are formed as solid forgings or castings, are to be machined to a smooth radius.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

Thrust Shaft

210 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1·05 times that required for the intermediate shaft as determined by 203; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

211 The diameter of the tube shaft which passes through the stern tube but does not carry the propeller, is not to be less than 1·05 times that required for the intermediate shaft as determined by 203, and any part of the shaft within the tube which may be exposed to sea water is not to be less than 1·075 times the diameter required for the intermediate shaft as determined by 203.

Screw Shaft

212 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in inches} = d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in inches, as determined by 203,

P = diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner,

100 when the shaft is not fitted with a continuous liner.

213 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times that required for the intermediate shaft.

Hollow Shafts

214 Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

Bronze Liners on Shafts

215 The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula:—

$$t = \frac{d + 9{\cdot}25}{32}$$

where t = thickness of the liners, in inches,

d = diameter required for the screw or tube shaft under the liner, in inches.

216 The thickness of a continuous liner between the bushes is not to be less than ·75t.

217 Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

218 Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

219 If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

220 Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

Stern Bush

221 The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required by Rule for the screw shaft under the liner.

Coupling Bolts

222 With coupling bolts of ordinary mild steel having a minimum tensile strength of 28 tons per square inch, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of coupling bolts,}\\ \text{in inches or millimetres}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d = diameter, in inches or millimetres, required for the intermediate shaft, as determined by H 203, H 303 or H 304, whichever is applicable,

n = number of bolts in the coupling,

r = radius of the pitch circle of the bolts, in inches or millimetres.

Couplings

223 The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling as determined by 221. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft as determined by H 203, H 303 or H 304, whichever is applicable.

224 The fillet radii at the base of flanges should not be less than ·125 of the diameter of the shaft.

225 Where couplings are separate from the shafts provision is to be made to resist the astern pull.

Bronze propellers

226 Where bronze is used for propellers or propeller blades, it is to comply with the requirements of P 10.

Section 3

TURBINES AND PROPELLING MOTORS

Dimensions of Shafts

301 The intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28–32 tons per square inch, are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of torsional vibration arising in the shafting and gearing.

With turbines or electric motors geared to the shafting and situated aft, calculations of the torsional vibration characteristics for the dynamic system formed by the turbine, motor, gearing, line shafting and propeller are to be submitted for consideration together with plans of all shafting and propeller and details of power developed by individual turbines throughout the speed range.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the vibration torques, as evidenced by tooth separation and gear hammer, are considered to be excessive.

302 Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Turbines and Electric Propelling Motors

303 The diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in inches}\end{array}\right\} = 3{\cdot}8\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum designed shaft horse power,

R = revolutions per minute at maximum power.

Steam Reciprocating Engines combined with Exhaust Steam Turbines

304 Where steam reciprocating engines are combined with exhaust steam turbines by means of mechanical gearing the diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of intermediate}\\ \text{shaft, in inches}\end{array}\right\} = 3{\cdot}8\sqrt[3]{\frac{SHP}{R}}$$

where SHP = maximum combined shaft horse power at the intermediate shaft,

R = revolutions per minute at maximum power.

NOTE: The s.h.p. of a reciprocating engine may be taken as 90 per cent of the indicated horse power.

The diameter of the straight shafting should in no case be less than required for the reciprocating engine when working without a turbine.

The sizes of thrust, tube and screw shafts are to be determined by H 210 to H 213 or by 307 to 310 whichever are the greater.

NOTE: The rule diameter of the intermediate shaft as determined by 303 or 304 may be reduced by 3·5 per cent for ships classed exclusively for smooth water service and by 1·75 per cent for ships classed exclusively for service on the Great Lakes.

Wheel Shafts of Geared Turbines

305 Where there are two pinions geared into the wheel, opposite, or nearly opposite, to one another, the diameter of the wheel shaft is not to be less than 1·1 times that required for the intermediate shaft.

306 Where there is only one pinion geared into the wheel, or where there are two pinions which are set to subtend an angle at the centre of the shaft of less than 120 degrees, the diameter of the shaft at the wheel and the adjacent journals is not to be less than 1·16 times that required for the intermediate shaft. Abaft the journals the shaft may be gradually tapered down to the diameter required for the intermediate shaft.

Thrust Shaft

307 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1·1 times that required for the intermediate shaft; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

308 The diameter of the tube shaft (i.e. the shaft which passes through the stern tube but does not carry the propeller) is not to be less than 1·05 times that required for

the intermediate shaft, and any part of the shaft within or without the tube which may be exposed to sea water is not to be less than 1·075 times that required for the intermediate shaft.

Screw Shaft

309 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in inches} = 1{\cdot}05\ d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in inches,

P = diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner,

100 when the shaft is not fitted with a continuous liner.

310 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times that required for the intermediate shaft.

Cross-references

311 For requirements for hollow shafts, shaft liners, stern bush, coupling bolts, couplings and propellers *see* H 214 to H 226.

Section 4

GENERAL REQUIREMENTS FOR STEAM RECIPROCATING ENGINES AND STEAM AND GAS TURBINES

Steam Reciprocating Engines

401 Explosion relief devices are to be fitted to the crank cases of enclosed forced lubricated steam reciprocating engines where the crank case volume is 20 cubic feet and over. The arrangement and sizes of the relief devices are to comply with the requirements of H 712 to H 715 where applicable. There is also to be compliance with H 717.

402 Auxiliary steam engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of ±0·5 per cent.

Hydraulic Tests

403 The cylinders of steam reciprocating engines are to be tested by hydraulic pressure as follows:—

COMPOUND EXPANSION ENGINES:

H.P. Cylinder	WP × 1·5
L.P. Cylinder	30 lb. per square inch.

TRIPLE EXPANSION ENGINES:

H.P. Cylinder	WP × 1·5
I.P. Cylinder	WP × ·5
L.P. Cylinder	30 lb. per square inch.

QUADRUPLE EXPANSION ENGINES:

H.P. Cylinder	WP × 1·5
First I.P. Cylinder ...	WP × ·6
Second I.P. Cylinder ...	WP × ·4
L.P. Cylinder	30lb. per square inch.

Where WP is the boiler working pressure in lb. per square inch.

Astern Power

404 Ships are to have sufficient power for going astern to secure proper control of the ship in all normal circumstances.

Trials

405 The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions.

STEAM AND GAS TURBINES

General

406 The following requirements are applicable, except where otherwise stated, to steam and gas turbines for main propulsion and for essential auxiliary services where powers exceed 150 s.h.p. Features of gas turbine machinery which are not included in this section will be specially considered.

Plans

407 The following plans are to be submitted for consideration, together with particulars of materials and of maximum designed powers and speeds. The pressures and temperatures applicable at full power and under the emergency conditions of 443 are to be stated or indicated on the plans.

1. General arrangement.
2. Sectional assembly.
3. Rotors and couplings.
4. Cylinders.
5. Combustion chamber and heat exchangers.

For main steam turbines plans 1, 2 and 3 are required in all cases and 4 when the cylinders are of welded construction. In general for auxiliary steam turbines no plans need be submitted. For main and auxiliary gas turbines plans 1 to 5 are required.

Where rotors and cylinders are of welded construction plans showing details of the welded joints are also to be submitted for consideration.

Materials

408 Plates, forgings, castings and pipes used in the construction of turbine cylinders, rotors, couplings and other important components are to be of approved composition and be tested in accordance with the relevant requirements of Chapter P, or of an approved Specification.

409 In the selection of materials for high temperature applications in advanced steam and gas turbines consideration is to be given to their creep strength, corrosion resistance and scaling properties at working temperature to ensure satisfactory performance and long life under service conditions.

Stability Testing of Turbine Rotors

410 All solid forged H.P. steam and gas turbine rotors intended for main propulsion service where the inlet steam or gas temperature exceeds 750° F. (400° C.) are to be subjected to at least one thermal stability test. This requirement is also applicable to rotors fabricated as in 426. The test may be carried out at the Forge or Turbine Builders' Works (*a*) after heat treatment and rough machining of the forging, or (*b*) after final machining, or (*c*) after final machining and blading of the rotor. The stabilising test temperature is to be not less than 50° F. (28° C.) above the maximum steam or gas temperature to which the rotor will be exposed and not more than the tempering temperature of the rotor material. For details of a recommended test procedure and limits of acceptance see P 6. Other test procedures may be adopted if approved.

Where main turbine rotors are subjected to thermal stability tests at both Forge and Turbine Builders' Works the foregoing requirements are applicable to both tests. It is not required that auxiliary turbine rotors be tested for thermal stability, but if such tests are carried out, the requirements for main turbine rotors will be generally applicable.

Design and Construction

411 In the design and arrangement of turbine machinery adequate provision is to be made for the relative thermal expansion of the various turbine parts, and special attention is to be given to minimising casing and rotor distortion under all operating conditions.

412 Indicators for determining the axial position of rotors relative to their casings and for showing the longitudinal expansion of casings at the sliding feet, if fitted, are to be provided for main turbines. The latter indicators should be fitted at both sides and be readily visible.

413 Pipes and ducts connected to turbine casings are to be so designed that no excessive thrust loads or moments are applied by them to the turbines. Gratings and any fittings in way of sliding feet or flexing-plate supports are to be so arranged that casing expansion is not restricted. Where main turbine seatings incorporating a tank structure are proposed, consideration is to be given to the temperature variation of the tank in service to ensure that turbine alignment will not be adversely affected.

414 In arranging the gland-sealing system of steam turbines the pipes are to be made self-draining and every precaution is to be taken against the possibility of condensed steam entering the glands and turbines. The steam supply to the gland-sealing system is to be fitted with an effective drain trap. In the air ejector recirculating water system the connection to the condenser is to be so located that water cannot impinge on the L.P. rotor or casing.

415 The turning gear for all propulsion turbines is to be power-driven and if electric is to be continuously rated.

416 Turbine rotors are to be made of forged material with a tensile strength for low alloy steel not exceeding 58 tons per square inch for solid rotors and 68 tons per square inch for the discs and spindles of built rotors. Where carbon steel forgings are adopted the tensile strength is not to exceed 45 tons per square inch. (*See* P 6.)

417 Discs of built rotors fitted by shrinking are to be secured with keys, dowels or other approved means in main turbines.

418 Smooth fillets are to be provided at abrupt changes of section of rotors, spindles, discs, blade roots and tenons. The rivet holes in blade shrouds are to be rounded and radiused on top and bottom surfaces and tenons to be radiused at junction with blade tips. Balancing holes in discs are to be well rounded and polished.

419 Surveyors are to be satisfied as to the workmanship and riveting of blades to shroud bands and that the blade tenons are free from cracks, particularly with high tensile blade material. Test samples are to be sectioned and examined and pull-off tests made if considered necessary by the Surveyors.

420 All rotors, as finished-bladed and complete with half coupling, are to be dynamically balanced in a machine of appropriate sensitivity for the size of rotor, to the Surveyor's satisfaction.

421 Turbine cylinder castings are to be of approved material suitable for the working metal temperature. Ordinary cast iron is not to be used for temperatures exceeding 500° F. (260° C.). The castings are to be stress relief heat treated after rough machining, except that this requirement may be waived for small castings at the Surveyor's discretion. The stress relieving temperature is not to exceed the tempering temperature. (*See* P 5 for Steel Castings.)

422 Turbine bearings are to be so disposed and supported that lubrication is not adversely affected by heat flow from adjacent hot parts of the turbine. Effective means are to be provided for intercepting oil leakage and preventing any oil from reaching high temperature glands and casings. Drainage openings from oil baffles are to be amply large. (*See* H 111 for alignment gauges.)

Welded Components

423 Turbine rotors, cylinders and associated components fabricated by means of welding will be considered for acceptance if constructed by firms whose works are properly equipped to undertake welding of equivalent standards, for rotors and cylinders respectively, to those required by the Rules for Class 1 and 2 Welded Pressure Vessels. (*See* J 19 and J 20.)

424 Welded combustion chambers, heat exchangers, gas collector vessels, pressure ducting and piping are to comply with the relevant sections of Chapters J (pressure vessels) and E (pipes).

425 Materials used in the construction of turbine rotors, cylinders, diaphragms, condensers, etc., are to be of welding quality.

426 Where it is proposed to construct rotors from two or more forged components joined by welding, full details of the chemical composition, mechanical properties and heat treatment of the materials, together with electrode particulars, an outline of the welding procedure, method of fabrication and heat treatment are to be submitted for consideration.

427 Joints in rotors and major joints in cylinders are to be designed as full strength welds and for complete fusion of the joint.

428 In the first instance and before work is commenced the Surveyors are to be satisfied that the desired quality of welding is attainable with the proposed welding procedure, and for this purpose test specimens representative of the welded joints are to be provided for radiographic examination and mechanical tests. For cylinders the mechanical tests of butt joints are to include tensile, bend and nicked bend tests as detailed in J 20. For diaphragms, nozzle plates, etc., representative samples are to be sectioned and macro etched. For rotors the mechanical tests are to include tensile (all weld metal), tensile (joint), bend (transverse), bend (longitudinal) and macro tests as detailed in J 19 or such other tests as may be approved. In subsequent production, check mechanical tests are to be carried out at the Surveyor's discretion if the quality of the welding is found to be unsatisfactory.

429 Adequate preheating is to be employed for mild steel cylinders and components where the metal thickness exceeds $1\frac{3}{4}$ inches and for all low alloy steel cylinders and components and for any part where necessitated by joint restraint.

430 Stress relief heat treatment is to be applied to all cylinders and associated components on completion of the welding of all joints and attached structures. (*See* J 1925 for details of stress relief procedure, temperature and duration.)

431 The heat treatment of welded rotors is to be carried out as approved.

432 Routine examinations by non-destructive methods are to be made of all cylinders and rotors on completion of heat treatment as follows:—

CYLINDERS.—Major stressed joints in pressure shells are to be radiographed if practicable; other joints such as nozzle plate and branch pipe connections and diaphragm joints are to be examined by crack detection methods.

ROTORS.—All joints are to be examined by radiography or other approved methods and by magnetic crack detection methods.

433 The whole of the welding work is to be to the satisfaction of the Surveyors.

Governors and other Safety Devices

434 An emergency overspeed governor is to be provided for main and auxiliary steam turbines so as to shut off the steam automatically and prevent the maximum designed speed being exceeded by more than 15 per cent.

435 Where two or more propulsion turbines are coupled to the same main gear wheel and only one emergency governor is provided, it is to be fitted to the L.P. ahead turbine. Hand trip gear for shutting off the steam in emergency is to be provided at the manœuvring platform.

436 Arrangements are to be made for the steam to the ahead propulsion turbines to be automatically shut off in the event of failure of the lubricating oil pressure. (*See* E 902 for emergency oil supply.)

437 Where a turbine installation incorporates a reverse gear, electric transmission or reversible propeller, a speed governor in addition to, or in combination with the emergency governor is to be fitted and is to be capable of controlling the speed of the unloaded turbine without bringing the emergency governor into action.

438 Auxiliary turbines intended for driving electric generators are to be fitted with speed governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm$ 0·5 per cent.

439 Sentinel relief valves are to be provided at the exhaust ends or other approved positions of all main steam turbines and the valve discharge outlets are to be visible and suitably guarded if necessary. Where a low vacuum cut-out valve is provided the sentinel relief valve at the L.P. exhaust may be omitted.

440 Non-return valves or other means, which will prevent steam and water returning to the turbines, are to be fitted in bled steam connections.

441 Efficient steam strainers are to be provided close to the inlets to ahead and astern high pressure turbines, or alternatively at the inlets to the manœuvring valves.

442 The governing and other safety devices for propulsion gas turbine installations will be specially considered.

Emergency Arrangements

443 In single screw ships fitted with steam turbines the arrangements are to be such that steam can be led direct to the L.P. turbine and either the H.P. or I.P. turbine can exhaust direct to the condenser. Adequate arrangements and controls are to be provided for these emergency conditions so that the pressure and temperature of the steam will not exceed those which the turbines and condenser can safely withstand.

Astern Power

444 Sufficient astern power is to be provided to maintain control of the ship in all normal circumstances and in general for this purpose the astern turbine or turbines of steam and free-piston gas turbine installations are to be designed to develop when operating astern under transient conditions 80 per cent of the ahead torque at 50 per cent of the ahead revolutions and to maintain in free route astern 70 per cent of the ahead revolutions for a period of at least 30 minutes without undue heating of the ahead turbines and condenser. The aforementioned ahead torques and revolutions are to be based on the maximum ahead power for which the machinery is to be classed.

Hydraulic Tests

445 Manœuvring valves are to be tested to twice the working pressure. The nozzle boxes of impulse turbines are to be tested to 1·5 times the working pressure.

The cylinders of all turbines are to be tested to 1·5 times the working pressure in the casing or to 30 lb. per square inch, whichever is the greater.

For test purposes the cylinders may be sub-divided with temporary diaphragms for distribution of test pressures.

Condensers are to be tested in the steam space to 15 lb. per square inch.

Trials

446 The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions. Where astern turbines or hydraulic reversing gear are fitted, astern running at 70 per cent of the full power ahead revolutions is to be demonstrated. The astern trial need only be of 15 minutes duration but may be extended to 30 minutes at the Surveyor's discretion. All trials are to be to the Surveyor's satisfaction.

Cross-references

447 Turbines intended for driving electric generators are to comply with the requirements of M 401 and M 402.

448 Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

449 The feed, bilge and general service pumps, steam and other pipes, cocks, sea connections, pumping arrangements and forced lubrication, are to comply with the requirements of Chapter E.

Section 5

REDUCTION GEARING FOR PROPELLING AND AUXILIARY MACHINERY

General

501 The following requirements, except where otherwise stated, are applicable to reduction gearing for main propelling purposes and for driving electric generators where the transmitted powers exceed 300 s.h.p. and 150 s.h.p. for propulsion and auxiliary drives respectively. In general, requirements are intended for helical type gears. Other types of gearing will be specially considered.

502 The materials for pinions, pinion sleeves, wheel rims, flexible couplings and quill shafts are to be of approved composition and mechanical properties and are to comply with the requirements of Chapter P. Manufacturers' certificates of test for materials may be accepted in cases where the transmitted power of gears is less than 150 s.h.p.

In the selection of materials for pinions and wheels consideration is to be given to their compatibility in operation; provision is also to be made for a hardness differential between pinion teeth and wheel teeth for which purpose the specified minimum tensile strength of the wheel rim material is to be not more than 85 per cent of that of the pinion. Normally, pinion materials are to have tensile strengths within the limits of 40 tons per square inch and 76 tons per square inch, but consideration will be given to the acceptance of materials of greater tensile strength if it is demonstrated that these can be machined satisfactorily. These requirements are not applicable to case-hardened and surface-hardened elements which will be specially considered.

503 Particulars of the gearing are to be submitted with the plans for all propulsion gears and for auxiliary gears where the transmitted power exceeds 150 s.h.p., as follows:—

Material specifications,
Shaft horse power and revolutions for each pinion,
Number of teeth in each gear,
Pitch circle diameters,
Helix angles,
Normal pitches of teeth,
Addenda,
Dedenda,
Face widths,
Pressure angles of teeth (normal or transverse),
Minimum backlash.

DESIGN

Tooth Form

504 The tooth profile in the transverse section is to be of involute shape and the roots of the teeth are to be formed with smooth fillets of radii, not less than 12 per cent of the normal pitch.

For propulsion gears the ends of the pinion and wheel teeth are to be cut back from the root at an angle of 45° to 60° to the pitch line in all cases where the ratio F/d exceeds 1·5.

where F = total axial length over pinion helices, less the gap, in inches,

d = pitch circle diameter of pinion, in inches.

The teeth of pinions and wheels of turbine gears are to be suitably tip-relieved in cases where any of the following conditions apply:—

(i) Normal pitch of teeth exceeds 0·7854 inch.

(ii) Addendum of pinion teeth exceeds 65 per cent of total working depth of engagement.

(iii) Ratio of total working depth of engagement to normal pitch of teeth exceeds 0·75.

All sharp edges left on the tips and ends of pinion and wheel teeth after hobbing or finishing are to be removed.

Tooth Loads

505 For turbine gears of the through-hardened type, tooth loads are to be governed by the requirements of 506. Where it is desired to adopt higher K values than permitted by the requirements of 506, full design calculations for tooth strength and pinion deflection are to be submitted for consideration.

For oil engine gears of the through-hardened type tooth loads are normally to be governed by requirements of 506. In cases of small gears or other special circum-

stances where it is desired to adopt higher loading than permitted by the formula, full particulars are to be submitted for consideration.

For turbine and oil engine gears of the surface-hardened and ground or case-hardened and ground type the tooth loads will be specially considered.

506 In order to limit the tooth surface stress the gear tooth load for maximum designed shaft horse power is not to exceed that given by the following formula:—

$$P = K \times d \times \frac{R}{(R + 1)}$$

where P = maximum permissible tooth load in lb. per inch of overall face width less gap,

K = loading factor to be derived from the expression:—

$C\,(40 + S)$ but not to exceed $C \times 110$,

C = coefficient, having values obtainable from Table 1,

S = specified minimum tensile strength of pinion material, in tons per square inch,

d = pitch circle diameter of pinion, in inches,

R = gear ratio:— $\frac{\text{pinion speed}}{\text{gear wheel speed}}$

TABLE 1

Service	Gear Type	Coefficient C	
Propulsion	Single Reduction	1	
Auxiliary	,, ,, ...	1·15	
Propulsion	Double Reduction	Primary	Secondary
	Split Secondary	1	0·85
	,, Primary	1	0·85
	Tandem	1	0·85
	,, Articulated ...	1·1	0·95
	Dual Tandem	0·9	0·85
	,, ,, Articulated ...	1	0·95

NOTE.—By "Articulated Gear" is meant the connecting of primary and secondary gears by a quill shaft and coupling which will permit adequate flexibility.

For typical arrangements of double helical, double reduction gears *see* Fig. 1.

Quill Shafts

507 The diameter of the quill shaft is to be not less than given by the following formula:—

$$\text{diameter of quill shaft, in inches} = 3{\cdot}5 \sqrt[3]{\frac{SHP}{R} \times \frac{28}{S}}$$

where SHP = maximum designed power,

R = revolutions per minute at maximum designed power,

S = specified minimum tensile strength of the material, in tons per square inch, which is not to be less than 28 tons per square inch.

CONSTRUCTION

Gear Wheels and Pinions

508 Where wheels are of cast construction any radial slots in the periphery are to be fitted with permanent chocks before shrinking of the rim.

When bolts are used to secure side plates to rim and hub, the bolts are to be a tight fit in the holes and not to be locked by welding.

When welding is employed in the construction of wheels, the welding procedure is to be approved in the first instance by the Surveyors before work is commenced. For this purpose, test specimens representative of the welded joints used in the construction of the wheel are to be provided for examination and mechanical test. Sections are also to be taken from the test joints at positions selected by the Surveyors, and are to be macro-etched to verify that the welds are sound. Wheels are to be stress relieved after welding. All welds are to have a smooth surface and even contour and are to be proved by magnetic crack detection methods.

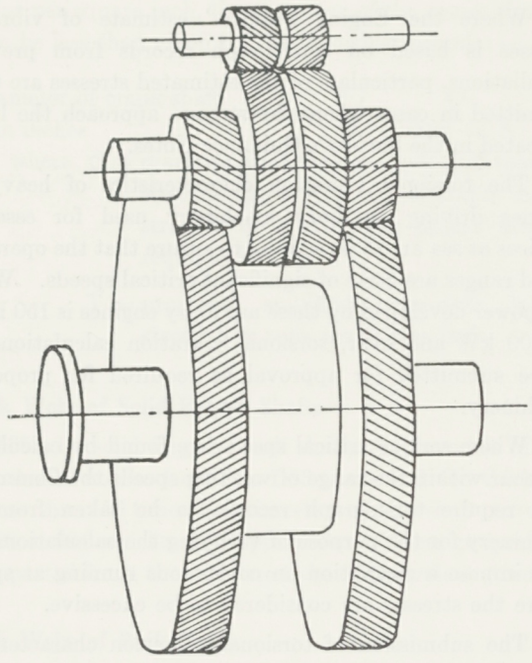
Gear Cases

509 Gear cases are to be of rigid design and if welding is employed in their construction they are to be stress relieved on completion. Provision is to be made by the gear manufacturers for verifying by trammels or other means during installation of the gear case on board ship that it is free from distortion when chocked and secured to its seating.

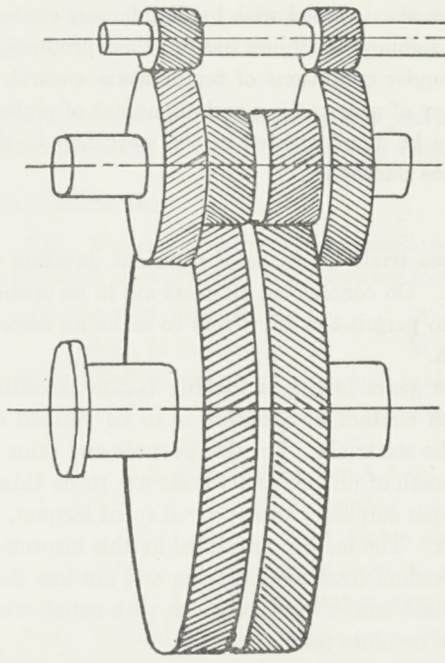
Balance of Gear Pinions and Wheels

510 All primary pinions over 12 inches diameter, complete with couplings, are to be dynamically balanced. All primary wheels, including those with secondary pinions, also main wheels are to be statically balanced.

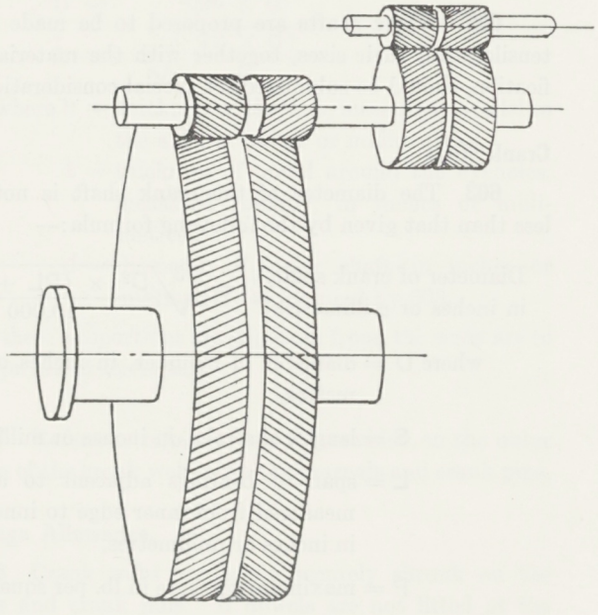
FIG. 1.—TYPICAL ARRANGEMENTS OF DOUBLE REDUCTION, DOUBLE HELICAL GEAR TRAINS



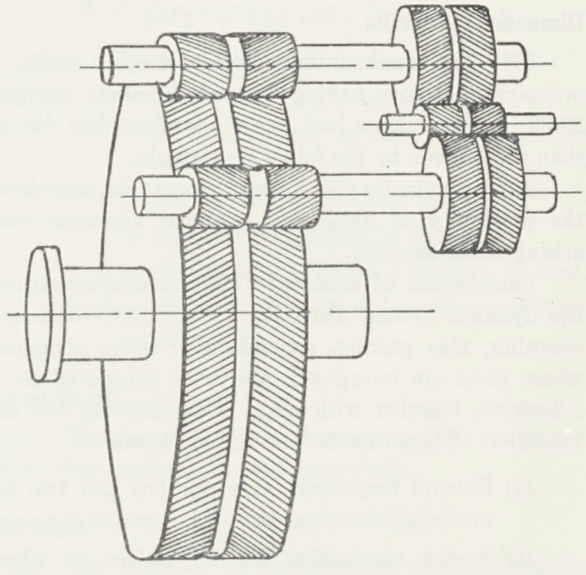
SPLIT SECONDARY



SPLIT PRIMARY



TANDEM



DUAL TANDEM

If flexible couplings are fitted between primary and secondary gears of "tandem" and "dual tandem" types, then these are described as "tandem articulated" and "dual tandem articulated", respectively.

Accuracy of Gear Cutting and Alignment

511 Turbine gearing is to be cut only on machines which are maintained at a high standard of accuracy. When large gears are designed with loading factors exceeding K=80, any hobbing machines used in their production are to operate under conditions of temperature control.

The accuracy of gear-cutting and alignment of pinions and wheels is to be demonstrated in the workshop to the satisfaction of the Surveyors.

Trials

512 The sea trials are to be of sufficient duration to prove the gears. On conclusion, all gears are to be opened up sufficiently to permit the Surveyors to make an inspection of the teeth.

For turbine gears having a loading factor exceeding K=80 the tooth contact distribution is to be verified on completion of the sea trials. For this purpose and prior to the trials, the teeth of pinions and wheels are to be thinly coated with copper sulphate, an approved spirit lacquer, or other equivalent. The marking revealed by this inspection is to indicate freedom from hard bearing and not less than 70 per cent contact across the face width with satisfactory contact over the involute profile.

Section 6

HEAVY OIL ENGINES

Dimensions of Shafts

601 The crank, intermediate and other shafts, if of ordinary mild steel having a tensile breaking strength of 28-32 tons per square inch, are to be of not less diameters than those given by the following formulæ.

The formulæ do not, however, take into consideration the possibility of dangerous torsional vibration stresses arising in the shafting.

Calculations of torsional vibration characteristics for the dynamic system formed by the engine, shafting and propeller, also gearing, generators or other components, where these are interposed, are to be submitted for consideration, together with plans of all shafting and of the propeller. These calculations should include:—

(*a*) Natural frequency tables for one and two noded modes of vibration, also higher modes if necessary.

(*b*) Vector summation for all orders of vibration occuring at speeds up to 20 per cent above the service speed.

(*c*) Particulars of the firing order in the case of four cycle engines.

Similar calculations are to be submitted for the system including the spare propeller, if supplied, where its design differs from that of the working propeller.

Where the Engine Builders' estimate of vibration stresses is based on torsiograph records from previous installations, particulars of the estimated stresses are to be submitted in cases where the stresses approach the limits indicated in the Society's Guidance Notes.

The torsional vibration characteristics of heavy oil engines driving auxiliary machinery used for essential services at sea are to be such as to ensure that the operating speed ranges are clear of significant critical speeds. Where the power developed by these auxiliary engines is 150 b.h.p. or 100 kW and over, torsional vibration calculations are to be submitted for approval as required for propelling machinery.

Where serious critical speeds are found by calculation to occur within the range of working speeds the Committee may require torsiograph records to be taken from the machinery for the purpose of verifying the calculations and may impose a restriction on continuous running at speeds where the stresses are considered to be excessive.

The submission of torsional vibration characteristics will not be required for ships classed for smooth water service when fitted with engines having powers less than 100 b.h.p.

602 Where shafts are proposed to be made of high tensile steel, their sizes, together with the material specification, should be submitted for special consideration.

Crank Shaft

603 The diameter of the crank shaft is not to be less than that given by the following formula:—

$$\text{Diameter of crank shaft, in inches or millimetres} = \sqrt[3]{\frac{D^2 \times (PL + CpS)}{10{,}000}}$$

where D = diameter of cylinder, in inches or millimetres,

S = length of stroke, in inches or millimetres,

L = span of bearings adjacent to a crank measured from inner edge to inner edge, in inches or millimetres,

P = maximum pressure in lb. per square inch,

p = mean indicated pressure in lb. per square inch,

C is a coefficient found from Table I, which follows after H 907.

604 Where it is proposed to make solid forged crank shafts of steel having a specified minimum tensile strength greater than 28 tons per square inch, but not exceeding 50 tons per square inch, the diameter of the crank shaft is not to be less than given by the following formula:—

$$\text{Diameter of crank shaft in inches} = d \times \sqrt[3]{\frac{28}{\cdot 72T + 8}}$$

where d = diameter, in inches, of crank shaft made of steel having a specified minimum tensile strength of 28 tons per square inch as required by 603.

T = proposed specified minimum tensile strength in tons per square inch.

Crank Webs of Solid Forged Shafts

605 In solid forged crank shafts the breadth of the webs should not be less than 1·33 times and the thickness not less than ·56 times the diameter of the shaft required by 603 or 604 whichever is applicable. If these proportions are departed from, the webs are to be of equivalent strength.

Crank Webs of Built Shafts

606 The dimensions of the crank webs of built shafts should not be less than those given by the following formulæ:—

$$h = \cdot 625 \times d$$

$$t = \sqrt{\frac{\cdot 12 \times d^3}{h}}$$

where h = thickness of the web, measured parallel to the axis, in inches or millimetres,

t = thickness of metal around the eyeholes, measured radially, in inches or millimetres,

d = diameter of crank shaft in inches or millimetres, as required by 603.

If these proportions are departed from, the webs are to be of equivalent strength.

607 Reference marks are to be provided on the outer junction of the crank webs with the journals and crank pins.

Shrinkage Allowance

608 Crank webs are to be securely shrunk on the journals and crank pins. If dowels are not fitted at the junction of the journals and webs, the yield point of the material of the webs is to be not less than 14 tons per square inch and the shrinkage allowance is to be between $\frac{1}{550}$ and $\frac{1}{700}$ of the diameter of the shaft.

Fillets and Oil Holes

609 Fillets at the junctions of crank webs with crank pins or journals, where these are formed as solid forgings or castings, are to be machined to a radius of not less than 5 per cent of the diameter of the crank shaft and are to have a smooth finish.

Oil holes at the surfaces of crank pins and journals are to be rounded to an even contour with a smooth finish.

Intermediate Shaft

610 The diameter of the intermediate shaft is not to be less than that given by the following formula:—

$$\text{Diameter of intermediate shaft, in inches} = C \sqrt[3]{\frac{BHP}{R}}$$

where BHP = maximum designed brake horse power.

R = revolutions per minute, at maximum power,

C is a coefficient found from Table II or III for single acting engines or from Table IV for double acting engines, by interpolation from the values found for A and the piston speeds.

Note: The Rule diameter of the intermediate shaft may be reduced by 3·5 per cent for ships classed exclusively for smooth water service and by 1·75 per cent for ships classed exclusively for service on the Great Lakes.

In using Tables II, III and IV the appropriate value A is found thus:—

$$A = \frac{D^2 \times S}{(Wd^2 + 6{\cdot}24\, wr^2) \times R^2}$$

where D = diameter of cylinder, in inches,

S = length of stroke, in inches,

R = revolutions per minute, at maximum power,

W = total weight of flywheel, in tons,

d = diameter of flywheel, in feet,

w = total weight of balance weights, in tons,

r = radius of gyration of balance weights, in feet.

Flywheel Shaft

611 The diameter of the flywheel shaft is to be not less than that required for the crank shaft.

Thrust Shaft

612 The diameter at the collars of the thrust shaft transmitting torque is not to be less than 1·1 times that required for the intermediate shaft; outside the collars the diameter may be tapered down to that required for the intermediate shaft.

Tube Shaft

613 The diameter of the tube shaft (i.e. the shaft which passes through the stern tube, but does not carry the propeller) is not to be less than 1·05 times that required for the intermediate shaft, and any part of the shaft within or without the tube which may be exposed to sea water is not to be less than 1·075 times that required for the intermediate shaft.

Screw Shaft

614 The diameter of the screw shaft carrying the propeller is not to be less than that given by the following formula:—

$$\text{Diameter of screw shaft, in inches} = 1{\cdot}05d + \frac{P}{C}$$

where d = diameter required for the intermediate shaft, in inches,

P = diameter of the propeller, in inches,

C = 144 when the shaft is fitted with a continuous liner,

100 when the shaft is not fitted with a continuous liner.

615 Screw shafts which run in stern tubes may have the end forward of the stern gland tapered down to a diameter, at the coupling flange, of 1·05 times that required for the intermediate shaft.

Hollow Shafts

616 Where the thrust, intermediate, tube and screw shafts have central holes, the dimensions of the shafts as determined by the foregoing formulæ need not be increased, provided the diameter of the central hole in a shaft does not exceed one-third of the shaft diameter.

Bronze Liners on Shafts

617 The thickness of liners fitted on screw shafts or on tube shafts, in way of the bushes, is not to be less, when new, than that given by the following formula:—

$$t = \frac{d + 9{\cdot}25}{32}$$

where t = thickness of the liner, in inches,

d = diameter required for the screw or tube shaft under the liner, in inches.

618 The thickness of a continuous liner between the bushes is not to be less than ·75 t.

619 Continuous liners should be cast in one piece or, if made of two or more lengths, the junctions of the separate pieces are to be made by fusion through the whole thickness of the liner.

620 Liners are to be carefully shrunk on, or forced on to the shafts by hydraulic pressure. Pins are not to be used to secure the liners.

621 If the liner does not fit tightly between the bearings in the stern tube, the space between the shaft and the liner is to be charged or forced with a plastic material insoluble in water and non-corrosive.

622 Effective means are to be provided for preventing water from having access to the shaft at the part between the after end of the liner and the propeller boss.

Stern Bush

623 The length of the bearing in the stern bush next to and supporting the propeller is not to be less than four times the diameter required by rule for the screw shaft under the liner.

Coupling Bolts

624 With coupling bolts of ordinary mild steel having a minimum tensile strength of 28 tons per square inch, the diameter of the bolts at the joining faces of the couplings is not to be less than that given by the following formula:—

$$\left.\begin{array}{l}\text{Diameter of the coupling bolts,}\\ \text{in inches or millimetres.}\end{array}\right\} = \sqrt{\frac{d^3}{3{\cdot}5 \times n \times r}}$$

where d = diameter, in inches or millimetres, required by 610 for the intermediate shaft in case of thrust, intermediate and screw shafts, and is ·95 of the diameter required by 603 for the crank shaft in the case of crank and flywheel shafts,

n = number of bolts in the coupling,

r = radius of the pitch circle of the bolts, in inches or millimetres.

Where the specified minimum tensile strength of the crank shaft is greater than 28 tons per square inch and the diameter of the shaft is determined by 604, the coupling bolts for this shaft are to be of equivalent strength.

Couplings

625 The thickness of the coupling flanges at the pitch circle of the bolt holes is not to be less than the diameter of the coupling bolts at the face of the coupling as determined by 624. The thickness of the screw shaft coupling flange is not to be less than ·25 of the diameter required for the intermediate shaft, as determined by 610.

626 The fillet radii at the base of flanges should not be less than ·125 of the diameter of the shaft.

627 Where couplings are separate from the shafts provision is to be made to resist the astern pull.

Bronze Propellers

628 Where bronze is used for propellers or propeller blades, it is to comply with the requirements of P 10.

Section 7

GENERAL REQUIREMENTS FOR HEAVY OIL ENGINES AND STARTING AIR COMPRESSORS

General

701 Special attention is to be given to the ventilation of the engine room.

702 Cylinder relief valves are to be fitted to engines of 8 inches bore or over. The valves are to be loaded to not more than 40 per cent above the designed maximum pressure and are to discharge where no damage can occur

703 Where scavenging is effected by a single independent scavenging blower alternative or duplicate means for driving the blower are to be provided ready for use.

704 Scavenge manifolds of main engines are to be provided with explosion relief valves.

705 The exhaust pipes and silencer are to be water cooled or efficiently lagged to prevent damage by heat; if the exhaust is led overboard near the water-line, means are to be provided to prevent water from being syphoned back to the engine.

Where the exhaust is cooled by water spray, the exhaust pipes are to be self-draining overboard.

Where the exhausts of two or more engines are led to a common silencer or exhaust gas-heated boiler or economiser an isolating device is to be provided in each exhaust pipe.

For alternately fired furnaces of boilers using exhaust gases and oil fuel, the exhaust gas inlet pipe is to be provided with an isolating device and interlocking arrangements whereby oil fuel can only be supplied to the burners when the isolating device is closed to the boiler.

706 An efficient governor is to be fitted to each main engine to prevent excessive racing.

707 Auxiliary engines intended for driving electric generators are to be fitted with governors which, with fixed setting, are to control the speed within the following limits:—

10 per cent momentary variation and 6 per cent permanent variation in speed when full load is suddenly taken off or put on, but for any A.C. installation the permanent speed variations of the machines intended for parallel operation are to be equal within a tolerance of $\pm$ 0·5 per cent.

Starting Arrangements

708 Equipment for starting the main and auxiliary engines is to be provided so that the necessary initial charge of starting air or initial electric power can be developed on board ship without external aid. If for this purpose an emergency air compressor or electric generator is required these units are to be power driven by hand starting oil engine or steam engine, except in the case of small installations where a hand operated compressor of approved capacity may be accepted.

709 Two or more starting and manœuvring air compressors are to be fitted of sufficient total capacity for the requirements of the main engines. Each compressor is to be fitted with a safety valve so proportioned and adjusted that the accumulation with the outlet valve closed will not exceed 10 per cent of the maximum working pressure. The casings of the cooling water spaces are to be fitted with a safety valve or bursting disc so that ample relief will be provided in the event of the bursting of an air cooler tube.

710 Where the main engines are arranged for air starting the total air receiver capacity is to be sufficient to provide, without replenishment, not less than twelve consecutive starts of each main engine if of the reversible type and not less than six consecutive starts if of the non-reversible type. In passenger ships, at least two air receivers are to be provided. For scantlings and fittings of air receivers *see* J 24.

711 Where main engines are fitted with electric starters, two batteries are to be fitted of sufficient combined capacity without recharging to provide the number of starts of the main engines as required by 710. In other respects batteries are to comply with the requirements of M 13.

Crank Case Safety Fittings

712 Crank cases are to be provided with lightweight spring-loaded valves or other quick-acting and self-closing devices to relieve the crank cases of pressure in the event of an internal explosion and to prevent any inrush of air thereafter. At least one of these valves should be fitted to each cylinder crank case. In the case of small auxiliary engines, where crank case and doors are inherently strong, one relief valve may be considered sufficient. In the case of small engines of less than 6 inches bore, relief valves may be

omitted. The discharge from the valves is to be shielded where necessary to minimise the possibility of danger and damage arising from the emission of flame.

713 The minimum sizes of relief valves are to be determined on a basis of 1 square inch of valve area per 5 cubic feet of crank case volume for engines with a crank case volume per cylinder of 100 cubic feet and over and on a basis of 1 square inch per 10 cubic feet, plus 10 square inches, for smaller engines. No valve is to be less than 3 inches diameter or equivalent area.

714 Crank cases are to be of robust construction and crank case doors are to be securely fastened so that they will not be readily displaced by an explosion.

715 Lubricating oil drain pipes from engine sump to drain tank are to be submerged at their outlet ends. Where two or more engines are installed, vent pipes, if fitted, and lubricating oil drain pipes are to be independent to avoid inter-communication between crank cases.

716 Crank cases of large starting air compressors are to be fitted with explosion relief devices as required for auxiliary engines in cases where the crank case volume is 20 cubic feet and over.

Crank Case Lighting

717 Where interior lighting is provided it is to be flame proof in relation to the interior and details are to be submitted for approval. No wiring is to be fitted inside the crank case.

Hydraulic Tests

718 Where main and auxiliary engine cylinder covers and cylinders not fitted with liners cannot be readily examined internally they are to be tested by hydraulic pressure to 1·5 times the maximum working pressure.

719 Air compressor cylinders, covers, intercoolers and aftercoolers are to be tested by hydraulic pressure to twice their maximum working pressure.

720 Cylinder liners are to be tested by hydraulic pressure to not less than 100 lb. per square inch.

721 The water jackets of cylinders, and the cooling passage of cylinder covers and pistons, are to be tested by hydraulic pressure to 30 lb. per square inch.

722 Fresh water and lubricating oil coolers are to be tested by hydraulic pressure to twice the working pressure with a minimum of 50 lb. per square inch on the fresh water and lubricating oil side, and a minimum of 30 lb. per square inch on the cooling water side.

Astern Power

723 Ships are to have sufficient power for going astern to secure proper control of the ship in all normal circumstances.

Trials

724 The sea trials are to be of sufficient duration to prove the machinery under power and normal manœuvring conditions.

It is to be demonstrated that the capacity of starting air receivers is adequate to provide the required number of starts of the main engines.

All trials are to be to the Surveyor's satisfaction.

Cross-references

725 Engines intended for driving electric generators are to comply with the requirements of M 4 and M 17 where applicable.

726 Where auxiliaries are worked by electricity, the cables, motors, control gear and electrical spares are to comply with the requirements of Chapter M.

727 The pumping arrangements, cooling water and lubricating oil systems are to comply with the requirements of Chapter E.

728 All oil fuel pipes, tanks and their fittings are to comply with the requirements of D 20 and Chapter E.

Spare Gear

729 For lists of spare gear to be carried, *see* Chapter K.

Periodical Surveys

730 For periodical survey requirements, *see* C 4 and C 6.

Section 8

STRENGTHENING FOR NAVIGATION IN ICE

801 Where the notation "Strengthened for navigation in ice Class 1, 2 or 3" is desired, the following requirements are to be complied with, so far as these are applicable.

Power of Propelling Machinery

802 The power delivered to the propeller shafting (s.h.p.) is not to be less than $\frac{L \times B}{C}$

Where L = length of ship, between perpendiculars, in feet,
B = breadth of ship, moulded, in feet,
C = coefficient given in Table I for each class.

Main Engine Shafting

803 The shafting and couplings are to be steel and the diameters of the shafting as required by the Rules for ocean-going service are to be increased by the percentages stated in Table 1. No increase in the diameter of crankshafts of heavy oil engines is required.

Gearing

804 If gearing is fitted between the engine and propeller shafting, the gearing is to be designed and constructed to transmit torque in excess of that corresponding to the engine power by the percentages given in Table I.

Turbines

805 Where turbines are used for the propulsion of ships intended for Class 1 or 2 ice strengthening, a slip coupling is to be fitted between the turbines and propeller shafting.

Electric Motors

806 Where direct current electric motors are used for the propulsion of ships intended for Class 1 or 2 ice strengthening, provision is to be made for automatically limiting the transmitted torque to a safe value.

Thrust Block

807 The area of the thrust surface of thrust blocks of ships intended for Class 1 ice strengthening is to be made at least 15 per cent greater than required for normal service.

For thrust blocks of the pivoted pad type the thrust pressure is not to exceed 300 lbs per square inch; for other types of thrust blocks the proposed thrust pressure is to be submitted for consideration.

Propellers

808 Propellers and propeller blades are to be of cast steel or bronze having a tensile strength and elongation of not less than 28 tons per square inch and 20 per cent on a gauge length of 2 inches. The material is to comply with the requirements of P 5 or P 10.

Propellers intended for Class 1 or 2 ice strengthening are to be designed so that the blade root and the blade tip thicknesses are not less than obtained by the following formulæ. Alternatively, a detailed stress computation for the blades is to be submitted for consideration.

Blade root thickness

$$T = K\sqrt{\frac{SHP \times 28}{R \times S \times N \times L}}$$

where $K = 22 - \frac{6P}{D} + \frac{AR}{84D}$ for ice class 1

$K = 20{\cdot}5 - \frac{6P}{D} + \frac{AR}{84D}$ for ice class 2

Blade tip thickness

$$t = \sqrt{\frac{D \times R}{100 \times S}}$$

where T = blade thickness at 25 per cent radius, in inches,

t = blade thickness at tip, in inches,

SHP = maximum designed shaft horse power,

R = revolutions per minute at maximum power,

D = propeller diameter, in feet,

P = mean pitch, in feet.

L = length of blade section at 25 per cent radius, in inches

A = rake, in inches,

N = number of blades,

S = tensile strength of material, in tons per square inch.

The blade thicknesses at sections between 25 per cent radius and the tip are not to be less than included by the straight lines joining thicknesses T and t. The edges of blades are to be suitably thickened for the operating conditions.

A plan, in triplicate, of the propeller, together with details of material, power and revolutions per minute and other particulars required for calculating the Rule thickness of the blades, are to be submitted for approval by the propeller designers.

TABLE 1

Class	1	2	3
Power Coefficient C	6·8	9·2	12·0
Screw Shaft, increase in diameter	15%	8%	5%
Crank, Thrust and Intermediate Shaft, increase in diameter ...	8%	4%	—
Gearing, torque increase	25%	15%	—
Thrust Block, increase in area of thrust surface	15%	—	—

Ship Side Valves

809 The sea inlet and overboard discharge valves which are situated below the maximum load line are to be provided with a low pressure steam or compressed air connection for clearing purposes.

810 Connections are to be fitted between the cooling water overboard discharge lines and sea inlets for main and auxiliary engine cooling water systems so that warm water may be used to assist in maintaining the suction pipes free from ice.

811 In motor ships where clearing steam is not available fire pumps are to be provided with suctions from the main cooling water inlet pipe.

Cross-references

812 For hull requirements *see* D 10 and for general requirements for ship side valves, *see* E 267 to E 271.

Section 9

WELDED STRUCTURES FOR STEAM RECIPROCATING AND HEAVY OIL ENGINES

General

901 The requirements of this section are applicable to engines for main propelling purposes.

Plans

902 Before construction is commenced plans of bedplates, crankcases, frames and entablatures, including details of the welded joints, materials, electrodes and heat treatment are to be submitted for consideration.

An outline of the welding procedure and fabrication method and sequence is also to be submitted for information.

NOTE: It will not be necessary for plans and particulars to be submitted for each ship provided the basis plans for the engine size and type have previously been approved as meeting the requirements of these Rules. Any alterations to basis design, materials and manufacturing procedure are to be re-submitted for consideration.

Materials

903 Plates, sections, forgings and castings are to be of welding quality to an approved specification with a carbon content generally not exceeding 0·23 per cent, and are to be tested in accordance with the requirements of Chapter P. Steels with higher carbon contents may be approved subject to special tests to prove weldability.

Welded Joints

904 Joints in parts of the engine structure which are stressed by the main gas, steam or inertia loads are to be designed as continuous full strength welds and for complete fusion of the joint. They are to be so arranged that, in general, welds do not intersect, and that welding and inspection can be effected without difficulty. Abrupt changes in plate section are to be avoided and where plates of substantially unequal thickness are to be butt welded, the thickness of the heavier plate is to be gradually tapered to that of the thinner plate. Tee joints are to be made with full bevel or equivalent weld preparation to ensure full penetration.

In single plate transverse girders the castings for main bearing housings are to be formed with web extensions which can be butt welded to the flange and vertical web plates of the girder. Stiffeners in the transverse girder are to be attached to the flanges by full penetration welds.

Construction

905 Plates and weld preparations are to be accurately machined or flame-cut to shape. Flame-cut surfaces are to be cleaned by machining or grinding; if the flame-cut surfaces are smooth, wire brushing may be accepted.

Before welding is commenced the component parts of bedplates and framework are to be accurately fitted and aligned. The welding is to be done in positions free from draughts and is to be downhand wherever practicable. Electrodes are to be of an approved type. Pre-heating is to be adopted when welding heavy plates or sections. The finished welds are to have an even surface and be free from undercutting. Welds attaching bearing housings to the transverse girders are to have a smooth contour and if necessary are to be made smooth by grinding.

Heat Treatment

906 Bedplates of heavy oil engines are to be stress relieved except for engine types where the bedplate as a whole is not subjected to direct loading from the cylinder pressure. For the latter types, and for all steam engines, only the transverse girder assemblies need be stress relieved.

Stress relieving is to be done by heating the welded structure uniformly and slowly to a temperature between 600° C. to 650° C. (1112° F. to 1202° F.), holding that

temperature for not less than one hour per inch of maximum plate thickness and thereafter allowing the structure to cool slowly in the furnace.

Inspection

907 Welded engine structures are to be examined during fabrication, special attention being given to the fit of component parts of major joints prior to welding. On completion of welding and stress relieving, all welds are to be examined. Welds in transverse girder assemblies are to be crack detected by an approved method to the satisfaction of the Surveyors. Other joints are to be similarly tested if required by the Surveyors.

The whole of the welding work is to be to the satisfaction of the Surveyors.

20th July, 1961

DESIGN RECOMMENDATIONS

It is recommended that bedplates and major components of engine structures should be made with a minimum number of welded joints.

Double welded butt type joints should be adopted wherever possible in view of their superior fatigue strength.

Girder and frame assemblies should, as far as possible, be made from one plate or slab shaped, as necessary, rather than by welding together a number of small pieces.

Steel castings should be used for parts which would otherwise require complicated weldments.

Care should be taken to avoid stress concentrations, such as sharp corners and abrupt changes in section.

TABLE I. FOR CRANK SHAFTS

Maximum Pressure 500 lb. per square inch and above

SINGLE ACTING ENGINES		
NUMBER OF CYLINDERS		C
4 STROKE CYCLE	2 STROKE CYCLE	
1, 2, 3 or 4	1 or 2	7·3
5 or 6	3	7·7
7 or 8	4	8·6
9 or 10	5	9·3
11 or 12	6	9·6
—	7	9·8
—	8	10·0
—	9	11·2
—	10	12·3
—	11	12·7
—	12	13·5

DOUBLE ACTING ENGINES		
NUMBER OF CYLINDERS		C
2 STROKE CYCLE		
3		7·2
4		13·4
4		8·7
5		11·3
6		13·1
6		12·0
6		16·6
7		13·8
8		15·4
8		29·3
9		16·8
10		19·4
10		25·0
11		22·0
12		23·0
12		28·9

TABLE II. FOR INTERMEDIATE SHAFTS OF 4 STROKE CYCLE SINGLE ACTING ENGINES

Maximum Pressure 500 lb. per square inch and above

NUMBER OF CYLINDERS	VALUE OF A	Value of C for following piston speeds in feet per minute.			
		700 and below	850	1000	1200 and above
1, 2, 3 or 4	·001	4·03	4·03	4·03	4·03
	·005	4·90	4·70	4·54	4·41
	·010	5·43	5·07	4·80	4·57
5	·001	3·96	3·96	3·96	3·96
	·005	4·53	4·38	4·26	4·16
	·010	4·85	4·59	4·38	4·26
6	·001	3·96	3·90	3·90	3·90
	·005	4·29	4·18	4·09	4·03
	·010	4·51	4·30	4·18	4·07
	·015	4·64	4·37	4·18	4·07
	No Flywheel or Balance Weights	5·00	4·54	4·29	4·13
7	·001	3·88	3·88	3·88	3·88
	·005	4·14	4·09	3·99	3·99
	·010	4·30	4·14	4·07	3·99
	·015	4·40	4·18	4·07	3·99
	No Flywheel or Balance Weights	4·63	4·29	4·12	4·03
8	·001	3·85	3·85	3·85	3·85
	·005	4·06	4·00	3·95	3·92
	·010	4·15	4·04	3·98	3·92
	·015	4·21	4·04	3·98	3·92
	No Flywheel or Balance Weights	4.35	4·12	4·02	3·96
9	·001	3·84	3·84	3·84	3·84
	·005 to ·015	4·04	3·96	3·92	3·90
	No Flywheel or Balance Weights	4·15	4·02	3·96	3·91
10	·001	3·82	3·82	3·82	3·82
	·005 to ·015	3·92	3·89	3·86	3·86
	No Flywheel or Balance Weights	4·01	3·93	3·90	3·86
11 and 12	All values including no Flywheel or Balance Weights	3·80	3·80	3·80	3·80

TABLE III. FOR INTERMEDIATE SHAFTS OF 2 STROKE CYCLE SINGLE ACTING ENGINES

Maximum Pressure 500 lb per square inch and above

NUMBER OF CYLINDERS	VALUE OF A	Value of C for following piston speeds in feet per minute.			
		700 and below	850	1000	1200 and above
1 or 2	·001	4·05	4·05	4·05	4·05
	·005	5·13	5·00	4·85	4·71
3	·001	3·90	3·90	3·90	3·90
	·005	4·47	4·32	4·27	4·18
	·010	4·88	4·64	4·46	4·31
4	·001	3·87	3·87	3·87	3·87
	·005	4·16	4·09	4·04	4·00
	·010	4·38	4·25	4·11	4·05
	·015	4·51	4·29	4·16	4·05
5	·001	3·84	3·84	3·84	3·84
	·005	3·97	3·94	3·90	3·90
	·010	4·07	4·00	3·93	3·90
	·015	4·11	4·03	3·93	3·90
	No Flywheel or Balance Weights	4·25	4·10	4·00	3·92
6	·001	3·82	3·82	3·82	3·82
	·005 to ·015	3·86	3·86	3·86	3·86
	No Flywheel or Balance Weights	3·94	3·86	3·86	3·86
7, 8, 9, 10, 11, and 12	All values including no Flywheel or Balance Weights	3·80	3·80	3·80	3·80

TABLE IV. FOR INTERMEDIATE SHAFTS OF 2 STROKE CYCLE DOUBLE ACTING ENGINES

Maximum Pressure 500 lb. per square inch and above

NUMBER OF CYLINDERS		VALUE OF A	Value of C for following piston speeds in feet per minute.			
			700 and below	850	1000	1200 and above
3		·001	3·86	3·86	3·86	3·86
		·005	4·09	4·04	3·99	3·99
		·010	4·28	4·15	4·07	4·01
		·015	4·39	4·25	4·10	4·04
		No Flywheel or Balance Weights	4·89	4·47	4·25	4·09
4		·001	3·91	3·91	3·91	3·91
		·005	4·30	4·19	4·09	4·04
		·010	4·54	4·33	4·18	4·09
		·015	4·66	4·40	4·25	4·09
		No Flywheel or Balance Weights	5·08	4·60	4·32	4·16
4		·001	3·85	3·85	3·85	3·85
		·005	3·94	3·91	3·88	3·88
		·010	4·01	3·95	3·91	3·88
		·015	4·05	3·97	3·91	3·88
		No Flywheel or Balance Weights	4·15	4·01	3·95	3·91
5		·001	3·82	3·82	3·82	3·82
		·005 to ·015	3·90	3·82	3·82	3·82
		No Flywheel or Balance Weights	3·95	3·90	3·86	3·86
6		·001	3·80	3·80	3·80	3·80
		·005 to ·015	3·91	3·88	3·84	3·84
		No Flywheel or Balance Weights	3·95	3·91	3·88	3·84
6		·001	3·80	3·80	3·80	3·80
		·005 to ·015	3·88	3·84	3·84	3·84
		No Flywheel or Balance Weights	3·91	3·87	3·84	3·84
6		·001	3·90	3·90	3·90	3·90
		·005	4·23	4·09	4·03	3·99
		·010	4·37	4·18	4·07	3·99
		·015	4·45	4·24	4·09	4·01
		No Flywheel or Balance Weights	4·66	4·31	4·13	4·04
7, 8, 9, 10, 11 and 12	EQUAL CRANK ANGLES	All values including no Flywheel or Balance Weights	3·80	3·80	3·80	3·80
8		·001	4·01	4·01	3·97	3·95
		·005	4·41	4·24	4·09	4·02
		·010	4·56	4·29	4·13	4·05
		·015	4·62	4·32	4·15	4·05
		No Flywheel or Balance Weights	4·78	4·39	4·18	4·07
10		·001	3·80	3·80	3·80	3·80
		·005 to ·015	3·94	3·90	3·86	3·86
		No Flywheel or Balance Weights	3·98	3·91	3·88	3·86
12		·001	3·80	3·80	3·80	3·80
		·005 to ·015 & No Flywheel or Balance Weights	3·89	3·86	3·84	3·84

Chapter J

BOILERS AND OTHER PRESSURE VESSELS

CYLINDRICAL BOILERS

Section 1

GENERAL REQUIREMENTS

101 In the design and construction of boilers the following conditions are to be observed.

102 The materials used are to be in accordance with the relevant requirements of Chapter P.

103 Where the joints in the shells of boilers are made by means of welding, the shells are to be constructed in accordance with the requirements of J 18 to J 23, in so far as they are applicable.

104 Where the joints in the shells of boilers are riveted, the shells are to be constructed in accordance with the requirements of J 5.

105 All steel plates which are welded, dished, flanged or locally heated are to be afterwards efficiently heat treated.

106 Butt straps are to be cut from plates and not from rolled strips.

107 All rivet holes are to be drilled, and as far as possible they are to be drilled in place. After drilling the plates the burrs are to be removed and the faying surfaces of the plates cleaned, and the sharp outer edges of holes also removed.

108 Steel stays are not to be welded. If plus threads are desired, the ends of the stay bars may be upset or the bars may be drawn down in the central portions from bars originally of the size of the ends. In either of these two cases the bars are to be subsequently annealed throughout. In double-ended boilers the through longitudinal stays are to be supported at or near the middle of their length.

109 Screw stays of combustion chambers where fitted with nuts are to be, as far as possible, normal to the chamber plates. Where this is not possible they are to be fitted with taper washers to provide a fair bed for the nuts.

110 Nuts to screw stays in combustion chambers are to be not less than $\frac{3}{4}$ inch thick for stays up to $1\frac{1}{2}$ inches diameter over threads, $\frac{7}{8}$ inch thick for $1\frac{5}{8}$ and $1\frac{3}{4}$ inch stays, 1 inch thick for $1\frac{7}{8}$ and 2 inch stays, and $1\frac{1}{8}$ inches thick for stays over 2 inches in diameter. The nuts are to be made of solid mild steel or of iron which is to be without weld. The nuts for longitudinal stays are to be to the British standards appropriate to the diameters of the stays, the outside nuts having the thickness therein provided for ordinary nuts, and the inside nuts having the thickness provided for lock nuts.

111 Screw stays $1\frac{1}{4}$ inches in diameter and above should have 9 threads per inch, and all stays 2 inches in diameter and above passing through plates, and secured by nuts on each side of the plate, should have not more than 6 threads per inch.

112 Where jointed longitudinal stays are fitted between the front and back tube plates they are to be fitted with pins having an effective sectional area not less than 25 per cent in excess of that of the stay. The pins may be slack in the holes, the total slackness being not more than $\frac{1}{16}$ inch. The pins are to be as close as possible to the shoulder of the eye forging. The shoulder of the forging is to have a diameter not less than 1 inch greater than the diameter of the hole.

113 The end plates in the steam space in way of uptakes are to be shielded from contact with the heated gases.

Cross-reference

114 For requirements as to smoke box doors and the omission of dampers in oil fired boilers, *see* E 332 and E 333.

Section 2

ACCESS ARRANGEMENTS

201 Manholes in cylindrical shells are to have their shorter axes arranged longitudinally. Where the cylindrical shell is cut for a manhole, compensation is to be provided and is to be such that the strength in way of the hole is not less than that required for the longitudinal joint.

202 Where a flat plate is flanged for stiffening it at a manhole or sight hole, to permit the same working pressure as would be allowed upon an unpierced plate, the depth of the flange measured in inches from the outer surface is to be at least equal to $\sqrt{T \times W}$ where T is the thickness of the plate in inches and W is the minor axis of the hole in inches.

203 The doors to manholes, mudholes, and sight holes are to be built up or pressed to shape and annealed, or made from one thickness of plate with a machined recess for the jointing material. Their spigot part or the recess

is not to have a greater clearance than $\frac{1}{16}$ inch all round, i.e., the axes of the opening are not to exceed those of the door by more than $\frac{1}{8}$ inch.

204 The studs for securing all doors are to be screwed through the plate, and they are to be fitted with nuts on the inside or bolts may be used screwed through the plate with the heads inside.

205 All boilers are to be provided, where possible, with means for ingress to permit of examination and cleaning of the inner surfaces of plates and tubes exposed to flame. Where the boilers are too small to permit of this there are to be sight holes and mudholes sufficiently large and numerous to permit of the inside being satisfactorily cleaned.

206 Where the cross tubes of vertical boilers are large there is to be a sight hole in the shell opposite to one end of each tube sufficiently large to permit the tube to be examined and cleaned. These sight holes are to be in positions accessible for that purpose.

Section 3

HYDRAULIC TESTS

Boilers

301 In all new boilers working at pressures up to 100 lb. per square inch the hydraulic test is to be twice the working pressure. For boilers working at pressures greater than 100 lb. per square inch the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Boiler Mountings

302 All boiler mountings are to be subjected to a hydraulic test of twice the working pressure with the exception of feed check valves which are to be tested to 2·5 times the working pressure. The test pressures need not, however, be more than 1000 lb. per square inch above the working pressure.

Section 4

BOILER MOUNTINGS AND FITTINGS

General

401 Valves over $1\frac{1}{2}$ inches diameter are to be fitted with outside screws and the covers are to be secured by bolts or studs. All valves are to be arranged to be shut with a right-hand (clockwise) motion of the wheels.

402 All cocks and valves connected to the boiler are to be such that it is seen without difficulty whether they are open or shut. Where boiler mountings are secured by studs, the studs are to have a full thread holding in the plate for a length of at least one diameter. If the stud hole penetrates the whole thickness of the plate the stud is to be screwed right through the plate and is to be fitted with a nut inside the boiler. Where bolts are used for securing mountings they are to be screwed right through the plate with their heads inside the boiler.

403 Where a superheater is fitted which can be shut off from the boiler it is to be provided with a separate safety valve fitted with easing gear. The valve as regards construction is to comply with the regulations for ordinary safety valves, but the easing gear may be fitted to be workable from the stokehold only. The superheater is also to be fitted with a drain cock or valve to free it from water when necessary.

404 Safety valve chests and other boiler and superheater mountings subjected to pressures exceeding 150 lb. per square inch or to steam temperatures exceeding 425° F., and boiler blow down fittings, are to be made of steel or other approved material.

Safety Valves

405 Boilers are to be fitted with not less than two safety valves, each having a minimum diameter of $1\frac{1}{2}$ inches, but vertical boilers having a total heating surface of less than 100 square feet may have one valve not less than 2 inches diameter.

406 The safety valves are to be so arranged that the springs and valves are cased in, that the valves cannot be overloaded when steam is up, that they can be lifted by easing gear and turned round on their seats by hand, and that in the case of fracture of springs they cannot lift out of their seats. The easing gear is to be operated by mechanical means from the boiler or engine room platforms.

Pilot valves which admit steam to their respective full lift valves are to be provided with suitable locking devices.

407 All the safety valves of each boiler may be fitted in one chest, which is to be separate from any other valve chest and is to be connected direct to the boiler by a strong and stiff neck, the passage through which is to be of not less cross sectional area than the aggregate area of the safety valves in the chest in the case of full lift valves and one-half of that area in the case of other valves. Each safety valve chest is to be provided with a means by which it can be drained; the drain pipe is to be led to the bilge or to a tank, clear of the boiler.

Saturated Steam

408 The minimum aggregate area of the orifices through the seatings of the safety valves on each boiler, whether coal fired, oil fired and/or exhaust gas fired and

whether working under natural, forced or induced draught, is to be found by the following formula :—

$$A = \frac{T.H.S. \times E}{(p + 15) \times C}$$

where A = *for ordinary, high lift or improved high lift safety valves*, the aggregate area in square inches of the orifices through the seatings of the valves,

for full lift safety valves, the net area in square inches through the seats after deducting the area of the guides or other obstructions when the valves are fully lifted,

T.H.S. = total external surface in square feet of the tubes and other parts of the boiler exposed to heat, so as to cause evaporation,

p = working pressure, in lb. per square inch,

E = estimated evaporation, in lb. per square foot of heating surface (T.H.S.) per hour, with a minimum value of 6, where the boilers are coal fired or oil fired and a minimum value of 3 for those parts of the boiler heated exclusively by exhaust gases,

C = 4·8 for valves of ordinary type,
7·2 for valves of high lift type,
9·6 for valves of improved high lift type,
19·2 for valves of full lift type.

In cases where the capacity of a high discharge type safety valve has been established by test, special consideration will be given, if desired, to the use of a higher constant than C=19·2, up to a maximum of C=30 for full bore safety valves.

SUPERHEATED STEAM

409 For valves which have to pass superheated steam, the aggregate area of the valves is to be the area A required by 408, multiplied by the factor :—

$$\left(1 + \frac{T}{1000}\right)$$

where T = degree of superheat, in degrees Fahrenheit.

410 An approved type of safety valve of equally good and reliable design may be fitted in lieu of those described in this Section.

Waste Steam Pipe

411 For ordinary, high lift and improved high lift type valves, the cross-sectional area of the waste steam pipe and passages leading to it, is to be not less than 10 per cent greater than the aggregate area of the safety valves as calculated by the foregoing formulæ ; for other valves, the cross-sectional area of the waste steam pipe and passages is to be not less than twice the aggregate valve area where C=19·2, and three times the aggregate valve area where C=30.

Accumulation Tests

412 All safety valves are to be set under steam to a pressure not greater than 3 per cent above the approved working pressure of the boiler. During a test of 15 minutes with the stop valves closed and under full firing conditions the accumulation of pressure is not to exceed 10 per cent of the loaded pressure. During this test no more feed water should be supplied than is necessary to maintain a safe-working water level.

413 For accumulation tests on the safety valves of water tube boilers, *see* J 1703 and J 1704.

Stop Valves

414 One main stop valve is to be fitted to each boiler secured direct to the shell. There are to be as few auxiliary stop valves as possible so as to avoid piercing the boiler shell more than is absolutely necessary. The arrangement, however, is to be such that where more than one boiler is fitted it is possible to supply the steam whistle, the steam steering gear, and the electric light machinery from at least two boilers.

Water Level Indicators on Cylindrical Boilers

415 Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass gauge. The other means is to be either an additional glass gauge or an approved equivalent device.

On double-ended boilers the above two water level indicators are to be fitted at each end, one indicator being positioned on each side.

On single-ended boilers, the water level indicators are also to be fitted one on each side of the boiler.

416 A set of not less than two test cocks will be accepted as the approved equivalent device mentioned in 415, for boilers having a working pressure less than 120 lb. per square inch or an internal diameter less than 6 feet.

The test cocks are to be fitted, where practicable, direct to the boiler plating.

417 The water gauges are to be readily accessible and placed so that the water level is clearly visible.

The lowest visible part of the glass of the water gauge and the lower test cock, where test cocks are fitted, are to be situated at the lowest safe working water level.

418 The level of the highest part of the effective heating surfaces, e.g. combustion chamber top of a horizontal boiler and the furnace crown of a vertical boiler, is to be clearly marked in a position adjacent to the glass water gauge.

419 The cocks of all water gauges are to be accessible from positions free from danger in the event of the glass breaking.

420 If the water gauges are not fitted directly to the shell of the boiler but to stand pillars or columns, it is desirable that these pillars or columns should be bolted directly to the shell of the boiler. If they are connected to the boiler by means of pipes the pipes are to be fitted with terminal cocks, not valves, secured direct to the boiler shell. For boilers exceeding 10 feet in diameter the pillars are to be not less than $2\frac{1}{2}$ inches and the connecting pipes not less than $1\frac{1}{2}$ inches internal diameter. For boilers exceeding 7 feet 6 inches but not exceeding 10 feet in diameter the pillars are to be not less than 2 inches and the pipes not less than $1\frac{1}{4}$ inches internal diameter, and for boilers 7 feet 6 inches in diameter and under the pillars are to be not less than $1\frac{3}{4}$ inches and the pipes not less than 1 inch internal diameter. The upper ends of the connecting pipes are to be so arranged that there is no pocket or bend where an accumulation of water from the condensation of the steam can lodge. They should not pass through the uptake if they can be otherwise arranged. If, however, this condition cannot be complied with, they may pass through it by means of a passage at least 2 inches clear of the pipe all round, open for ventilation.

421 For water level indicators on water tube boilers, *see* J 1706 and J 1707.

Feed Check Valves

422 Two feed check valves, connected to separate feed lines, are to be provided for all main, auxiliary and donkey boilers which are required for essential services with the exception of boilers in which steam is generated exclusively by exhaust gas or steam, where one feed check valve will be accepted. (*See* E 701.)

The feed check valves are to be attached, wherever practicable, direct to the boiler but where the arrangements necessitate the use of standpipes between the boiler and the check valves, these pipes are to be of steel or other approved material.

423 For boiler feed water systems, *see* E 7, and for feed water fittings on water tube boilers, *see* J 1708 and J 1709.

Pressure Gauges

424 Each boiler is to be provided with a separate steam pressure gauge. Double-ended boilers are to be provided with a pressure gauge at each end. The gauges are to be placed where they are easily seen.

Blow-down and Scum Valves

425 Each boiler is to be fitted with at least one blow-down valve secured direct to the lower part of the boiler.

Where it is not practicable to attach the blow-down valve direct to water tube boilers, the valve may be placed immediately outside the boiler casing with a steel pipe of substantial thickness fitted between the boiler and valve. The pipe and valve are to be suitably supported and any pipe which may be exposed to direct heat from the furnace is to be adequately protected.

The blow-down valve and its connections to the sea need not be more than $1\frac{1}{2}$ inches and is to be not less than $\frac{3}{4}$ inch in diameter. For cylindrical boilers the size of the valve may be generally $\frac{1}{10}$ inch in diameter for each foot in diameter of the boiler.

Vertical boilers are to be fitted with a blow-down valve or cock.

426 Blow-down valves and scum valves (where these latter are fitted) of two or more boilers may be connected to one common discharge, but where thus arranged there are to be screw-down non-return valves fitted for each boiler to prevent the possibility of the contents of one boiler passing to another.

For blow-down cock or valve on ship's side and attachments, *see* E 267 and E 268.

Salinometer Cock or Valve

427 Each boiler is to be provided with a salinometer cock or valve secured direct to the boiler in a convenient position. The cock or valve is not to be on the water gauge standpipe.

Section 5

RIVETED CYLINDRICAL SHELLS

501 For the cylindrical shells of steel marine boilers the maximum working pressure (which is designated by WP and is in lb. per square inch) to be allowed is to be calculated from the following formulæ:—

Where the thickness of the shell plates does not exceed $1\frac{3}{4}$ inches,

$$WP = \frac{(t-2) \times S \times J}{C \times D}$$

Where the thickness of the shell plates exceeds $1\frac{3}{4}$ inches and the longitudinal seams are made with double butt straps,

$$WP = \frac{t \times S \times J}{2{\cdot}85 \times D}$$

In these formulæ

t = thickness of the shell plates, in 32nds of an inch,

S = minimum tensile strength of the steel shell plates, in tons per square inch,

J = percentage of strength of the longitudinal seams calculated by the methods described in 502,

D = inside diameter of the outer strake of plating of the cylindrical shell, measured in inches,

C = 2·75 where the longitudinal seams are made with double butt straps,
2·83 where the longitudinal seams are made with lap joints and are treble riveted,
2·9 where they are made with lap joints and are double riveted,
3·3 where they are made with lap joints and are single riveted.

502 The percentage of strength of a riveted joint (J) is found from the following formulæ, the first two being applicable to any type of joint, and the third to that type of joint in which the number of rivets in the inner rows is double that in the outer row. The lowest value given by the application of these formulæ is to be taken as the percentage of strength of the joint.

$$\left.\begin{array}{l}\text{Percentage of strength of plate at}\\ \text{joint as compared with solid plate}\end{array}\right\} = \frac{100\,(p-d)}{p}$$

$$\left.\begin{array}{l}\text{Percentage of strength}\\ \text{of rivets as compared}\\ \text{with solid plate}\end{array}\right\} = \frac{100\,(S_2 \times a \times n \times C)}{S_1 \times p \times T}$$

Percentage of combined strength of the plate at the inner row of rivet holes and of the rivets in the outer row

$$= \frac{100\,(p-2d)}{p} + \frac{100\,(S_2 \times a \times C)}{S_1 \times p \times T}$$

where p = pitch of rivets at outer rows, in inches,

d = diameter of rivet holes, in inches,

a = sectional area of one rivet, in square inches,

n = number of rivets which are fitted in the pitch p,

T = thickness of plate, in inches,

S_1 = minimum tensile strength of plates, in tons per square inch,

S_2 = shearing strength of rivets, which is taken generally to be 23 tons per square inch, and may be 85 per cent of the minimum tensile strength of the rivet bars,

C = 1·0 for rivets in single shear as in lap joints, 1·875 for rivets in double shear as in double butt-strapped joints.

503 Where the longitudinal seams are fitted with double butt-strapped joints, the outer butt strap is to be at least ·625 of the strength of the plate, and is to be of sufficient thickness to permit of efficient caulking of its outer edges. The inner butt strap is to be $\frac{4}{32}$ inch thicker than this.

In cases where the number of rivets in the inner rows is double the number in the outer row, this will require the minimum thickness, in inches, of the outer strap (t_o) to be

$$t_o = \frac{5 \times (p-d)}{8 \times (p-2d)} \times T$$

and that of the inner strap (t_n) to be

$$t_n = \left\{ \frac{5 \times (p-d)}{8 \times (p-2d)} \times T \right\} + \tfrac{4}{32} \text{ inch.}$$

504 In all cases the clear space between a rivet hole and the edge of a plate is to be not less than the diameter of the rivet holes, i.e., the centre of the rivet hole is to be at least 1·5 diameters distant from the edge of the plate.

In joints whether lapped or fitted with butt straps, in which there are more than one row of rivets and in which there is an equal number of rivets in each row, the distance between the rows of rivets is to be not less than ·33p + ·67d with zigzag riveting, or 2d with chain riveting.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows, and in which the inner rows are chain riveted, the distance between the outer rows and the next rows is to be not less than ·33p + ·67d or 2d, whichever is the greater, and the distance between the rows in which there are the full number of rivets is to be not less than 2d.

In joints in which the number of rivets in the outer rows is one-half of the number in each of the inner rows and in which the inner rows are zigzag, the distance between the outer rows and the next rows is to be not less than ·2p + 1·15 d, and the distance between the rows in which there are the full number of rivets is to be not less than ·165p + 0·67d.

In the above p is the pitch of the rivets in the outer rows.

505 The maximum pitch, in inches, of the rivets in the longitudinal joints of boiler shells

$$= (C \times T) + 1\tfrac{5}{8} \text{ inches}$$

where T is the thickness of the plate in inches and C is a coefficient as given in the following Table :—

Number of rivets per pitch	Coefficients for lap joints	Coefficients for double butt-strapped joints
1	1·31	1·75
2	2·62	3·50
3	3·47	4·63
4	4·14	5·52
5	—	6·00

506 If holes are cut in the cylindrical shells of boilers for fixing of mountings, the diameters of the holes being greater than 2·5 times the thickness of the shell plating plus $2\frac{3}{4}$ inches, compensation is to be fitted as in the case of manholes. (*See* J 201.)

507 Where more than three screw stays pierce the cylindrical shell in a horizontal line, if d is their diameter and p the pitch, $\frac{100\,(p-d)}{p}$ should not be less than the percentage of strength required for the shell longitudinal joints. If this is not possible, stays are to be arranged out of line with one another longitudinally.

508 The strength of the seams joining the end plates to the cylindrical shell is not to be less than 42 per cent of that of the solid shell plate. Where the shell plates exceed $\frac{5}{8}$ inch in thickness the seams connecting the shell plates to the end plates are to be at least double riveted. Where the shell plates exceed $\frac{1}{2}$ inch in thickness the intermediate circumferential seams of double-ended boilers are to be at least double riveted.

509 The circumferential seam at or near the middle of the length of single-ended boilers is to have a strength of joint not less than 60 per cent of the solid plate. The inner circumferential seams of double-ended boilers are to have a strength of joint not less than 62 per cent of the solid plate. In any case there are to be at least three rows of rivets where single-ended boilers have shell plates over $1\frac{3}{8}$ inches in thickness and where double-ended boilers have shell plates over $1\frac{3}{16}$ inches in thickness.

510 The circumferential seams of the shells of vertical boilers are to have a strength of not less than 42 per cent of the solid plate. Where these seams are not complete circles, and where the shell plates exceed $\frac{5}{8}$ inch in thickness, the riveting is to be at least double.

Section 6

FURNACES

Note :—Furnaces, plain or corrugated, are not to exceed $\frac{1}{2}\frac{7}{6}$ inch in thickness.

Corrugated Furnaces

601 The working pressure to be allowed on corrugated furnaces is to be determined by the following formula :—

$$WP = \frac{C\,(t-1)}{D}$$

where WP = working pressure, in lb. per square inch,
D = external diameter measured at the bottom of the corrugations, in inches,
t = thickness of the furnace plate, in 32nds of an inch, measured at the bottom of the corrugation or camber,
C = 480 for the Fox, Morison, Deighton Purves and other similar furnaces,
510 for the Leeds Forge Bulb Suspension furnace.

Plain Furnaces and Combustion Chamber Bottoms

602 The working pressure to be allowed on plain furnaces or furnaces strengthened by the Adamson or other joints, and on the cylindrical bottoms of combustion chambers, is to be determined by the following formulæ, the least pressure obtained by either formula being taken :—

$$WP = \frac{C\,(t-1)^2}{(L+24)\times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [10\,(t-1) - L]$$

where WP = working pressure, in lb. per square inch.
D = external diameter of the furnace or combustion chamber, in inches,
t = thickness of the plate, in 32nds of an inch,
L = length of the furnace or of combustion chamber bottom or the length between points of substantial support, in inches, measured from the centres of the rivet rows or from the commencement of flange curvature, whichever is applicable,
C = 1450 where the longitudinal seams are welded and 1300 where they are riveted,
C_1 = 50 where the longitudinal seams are welded and 45 where they are riveted.

603 Where the furnaces are tapered, the diameter to be taken for calculation purposes is to be the mean of that at the top and of that at the bottom where it meets the substantial support from flange or ring. The length for the same purpose is to be the distance from the centre of the row of rivets connecting the crown to the body of the furnace, to the substantial support at the bottom of the furnace or to a row of screwed stays connecting the furnace to the shell, provided the pitch of stays at the furnace does not exceed 14 times the thickness of the furnace plate where the stays are riveted at their ends, and 16 times where they are fitted with nuts. Such screwed stays are to be in diameter over the threads not less than 2·25 times the thickness of the furnace plate.

Furnaces of Spherical Form

604 Where the furnaces are spherical in form and convex upwards at their tops, and are without support

from stays of any kind :—

$$WP = \frac{275\ (t - 1)}{R}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the top plate, in 32nds of an inch,
R = outer radius of curvature of the furnace in inches.

Uptakes of Vertical Boilers

605 The working pressure to be allowed on internal uptakes of vertical boilers is to be determined by the following formulæ, the least pressure obtained by either formula being taken :—

$$WP = \frac{C\ (t - 5)^2}{(L + 24) \times D}$$

$$\text{or } WP = \frac{C_1}{D} \times [10\ (t - 5) - L]$$

where WP = working pressure, in lb. per square inch,
D = external diameter of the uptake, in inches,
t = thickness of the uptake, in 32nds of an inch,
L = length of the uptake between points of substantial support, in inches, measured from the centres of the rivet rows,
C = 1450 where the longitudinal seams are welded and 1300 where they are riveted,
C_1 = 50 where the longitudinal seams are welded and 45 where they are riveted.

Cross Tubes

606 The thickness of cross tubes in cross tube boilers is to be determined from the following formula, but is in no case to be less than $\frac{3}{8}$ inch :—

$$t = \frac{WP \times D}{200} + 7$$

where WP = working pressure, in lb. per square inch,
t = minimum thickness, in 32nds of an inch,
D = internal diameter of the cross tube, in inches.

Ogee Rings

607 For the ogee ring which connects the bottom of the furnace to the shell, and sustains the whole load on the furnace vertically :—

$$WP = \frac{140\ (t - 1)^2}{D \times (D - d)}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the ogee ring, in 32nds of an inch,
D = inside diameter of the boiler shell, in inches,
d = outside diameter of the lower part of the furnace where it joins the ogee ring, in inches.

Section 7

FLAT PLATES SUPPORTED BY STAYS SECURED IN VARIOUS WAYS

701 The working pressure to be allowed on flat plates supported by stays is to be calculated by the following formula :—

$$WP = \frac{(t - 1)^2 \times C}{a^2 + b^2}$$

In this formula and in the formulæ in 708 to 711

WP = working pressure, in lb. per square inch,
t = thickness of the flat plate, in 32nds of an inch,
t_w = thickness of the washers, strips, or doublings employed, in 32nds of an inch,
a = distance apart of the rows of stays, in inches,
b = pitch of the stays in the rows, in inches,
C is a coefficient which varies with the method of fixing the stays as follows :—

Where the plates are exposed to flame and the stays are screwed into the plate and their ends are riveted over, C = 50. Where the plates are not exposed to flame and the stays are screwed into the plate and their ends are riveted over, C = 57. In these cases the thickness of the plate is to be at least half the diameter of the stay required by the Rules.

Where stay tubes are screwed into tube plates and expanded, C = 52. If they are fitted with nuts, C = 72.

Where the plates are exposed to flame and the stays are screwed into the plate and fitted with nuts on the outside, C = 75. Where the plates are not exposed to flame, C = 86.

Where the stays pass through the plates not exposed to flame and are fitted with nuts inside and outside, C = 96, and where the plates are exposed to flame, C = 84.

702 Where plates are stiffened by flanging, the inner radius of which is not greater than 2·5 times the thickness of the plate, for the support thus given C = 110 where the plates are not exposed to flame and C = 96 where they are exposed to flame. The pitch is to be reckoned from the commencement of the curvature.

703 For portions of plate where the stays are irregularly pitched d^2 is to be used instead of $a^2 + b^2$, d being the diameter of the largest circle which can be drawn passing through not less than three points of support, i.e., the centres of stays or the commencement of the curvature of flanging whichever is applicable. In this case C is to be taken as the mean of the values appropriate for the points of support.

704 For the tops and sides of combustion chambers the distance between the rows of stays nearest to the back tube plate or the back plate respectively and the commencement of curvature of these plates at their flanges is to be not greater than a.

705 The stays of the combustion chambers are to be so placed that the seams of the plates can be caulked without removing the stay nuts.

706 For the tops of combustion chambers where they are joined to the sides by curved portions, if the outer radius of the curved portion is less than half the allowable distance between the girders, the distance between the first girder and the inner surface of the side plate is not to exceed the allowable distance between the girders. If the radius of the curved portion is greater than half the allowable distance between the girders, the width of the flat portion measured from the centre of the girder is to be not more than half the allowable distance between the girders.

707 Where portions of plate are supported by stays secured in different ways the value of C to be taken is the mean of the values appropriate to the method of securing the supporting stays.

708 Where the plate is supported by stays which pass through it and are fitted with nuts inside and washers and nuts outside, the diameter of the washers being at least 3·5 times that of the stay, and their thickness at least two-thirds of that of the plate but not greater than that of the plate :—

$$WP = \frac{100}{a^2 + b^2}\left[(t - 1)^2 + \cdot 15\ t_w^2\right]$$

709 Where the washers have a diameter of at least two-thirds of the pitch of the stays and a thickness of at least two-thirds of the thickness of the plate but not greater than that of the plate and are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2}\left[(t - 1)^2 + \cdot 35\ t_w^2\right]$$

710 Where the plate is stiffened by strips at least two-thirds of the pitch of the stays in breadth and having a thickness at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2}\left[(t - 1)^2 + \cdot 55\ t_w^2\right]$$

711 Where the plate is fitted with doubling plates having a thickness of at least two-thirds of that of the plate but not greater than that of the plate and which are riveted to the plate in an efficient manner :—

$$WP = \frac{100}{a^2 + b^2}\left[(t - 1)^2 + \cdot 85\ t_w^2\right]$$

712 For the portions of tube plates in the nests of tubes :—

$$WP = \frac{C\ (t - 1)^2}{p^2}$$

where WP = working pressure, in lb. per square inch,

t = thickness of the tube plate, in 32nds of an inch,

p = mean pitch, in inches, of the stay tubes supporting any portions of the plate (being the sum of the four sides of the quadrilateral divided by 4),

C = 38 where the stay tubes are screwed and expanded into the plate and nuts are not fitted,

49 where the stay tubes are screwed and expanded into the plate and fitted with nuts. (*See* J 1206.)

713 For the wide water spaces of front tube plates between the nests of tubes and between the wing rows of tubes and the shell :—

$$WP = \frac{C[(t-1)^2 + \cdot 55 t_w^2]}{a^2 + b^2}$$

where WP = working pressure, in lb. per square inch,

t = thickness of the front tube plate, in 32nds of an inch,

t_w = thickness of the doubling plate, where so fitted, in 32nds of an inch,

a = horizontal pitch of stay tubes, in inches, measured across the wide water space,

b = vertical pitch of stay tubes in the bounding rows, in inches, measured from centre to centre,

C = 52 where the stay tubes are screwed and expanded into the tube plate and nuts are not fitted,
72 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted to each stay tube,
63 where the stay tubes are screwed and expanded into the tube plate, and nuts are fitted only to alternate stay tubes.

714 If steel of less strength than 26 tons per square inch is used for flat plates, the working pressure allowed is to be correspondingly reduced.

Section 8

TUBE PLATES UNDER COMPRESSION

801 The pressure to be allowed on tube plates is to be calculated by the following formula, in which the compressive stress is taken at 14,000 lb. per square inch :—

$$WP = 875 \times \frac{(D - d) \times t}{W \times D}$$

where WP = working pressure, in lb. per square inch
t = thickness of the tube plate, in 32nds of an inch,
D = horizontal distance apart of the tubes, centre to centre, in inches,
d = internal diameter of the plain tubes, in inches,
W = width of combustion chamber, in inches, measured inside from tube plate to back chamber plate, or between tube plates in double-ended boilers with combustion chambers common to two opposite furnaces.

Section 9

TUBE PLATES OF VERTICAL BOILERS

901 Where vertical boilers have a nest or nests of horizontal tubes so that there is direct tension on the tube plates due to the vertical load on the boiler ends or to their acting as horizontal ties across the shell, the thickness of the tube plates and the spacing of the tubes are to be such that the section of metal taking the load is sufficient to keep the stress within that allowed on the shell plates.

902 Each alternate tube in the outer vertical rows of tubes is to be a stay tube. The tube plates between the stay tubes are to be in accordance with J 712 and in addition :—

$$WP = \frac{(t - 2) \times S \times (p - d) \times 100}{2{\cdot}9 \times D \times p}$$

where WP = working pressure, in lb. per square inch,
S = minimum tensile strength of the steel plate, in tons per square inch,
t = thickness of the tube plate, in 32nds of an inch,
D = twice the radial distance of the centre of the outer row of tube holes from the axis of the shell, in inches,
p = vertical pitch of tubes, in inches,
d = diameter of the tube holes, in inches.

The least working pressure obtained by the above formula and that in J 712 is to be taken.

Section 10

GIRDERS

1001 For girders supporting the tops of combustion chambers the following formula is to be used :—

$$WP = \frac{C \times d^2 \times t}{(L - P) \times D \times L} \times \frac{S}{28}$$

where WP = working pressure, in lb. per square inch,
d = depth of the girder at centre, in inches,
t = thickness of the girder at centre, where this is a forging, or the sum of the thicknesses of the plates where the girder is made of two plates, measured in 32nds of an inch,
L = length of the girder, in inches, measured between the tube plate and back chamber plate inside, or between tube plates in chambers common to two opposite furnaces,
P = pitch of stays supported by the girder, in inches,
D = distance apart of the girders, centre to centre, in inches,
S = minimum tensile strength of the material forming the girder, in tons per square inch.

$C = \frac{n}{n + 1} \times 495$, where the number of stays (n) in each girder is odd,

$\frac{n + 1}{n + 2} \times 495$, where the number of stays (n) in each girder is even.

Section 11

STAYS

Screw Stays

1101 For steel screw stays with threads not coarser than 9 threads per inch, the following formula is to be used, but in no case is the stress to exceed 9,000 lb. per square inch :—

$$WP = \frac{(d - \cdot 267)^2 \times 8250}{a}$$

where WP = working pressure, in lb. per square inch,

d = diameter of the stay over the thread, in inches,

a = area, in square inches, supported by one stay.

Longitudinal Stays

1102 For steel longitudinal stays with threads not coarser than 6 threads per inch the working pressure is to be calculated from the following formula, but in no case is the stress to exceed

$$\frac{\text{minimum specified tensile strength in lb. per square inch}}{\cdot 5 \cdot 7}$$

$$WP = \frac{(d - \cdot 340)^2 \times 9500}{a} \times \frac{S}{28}$$

where WP = working pressure, in lb. per square inch,

d = diameter of the stay over the thread, in inches,

a = area, in square inches, supported by one stay,

S = minimum tensile strength of the steel, in tons per square inch.

1103 In cases where longitudinal stays are made with enlarged ends and the body of the stay is smaller in diameter than at the bottom of the thread, and in cases where coarser threads than 6 per inch are used, the working pressure is to be calculated from the following formula :—

$$WP = \frac{(d^1 - \cdot 125)^2 \times 9500}{a} \times \frac{S}{28}$$

d^1 = diameter of the stay at the bottom of the thread, in inches, or at the smallest part of the body.

Other symbols as defined in 1102.

Cross-reference

1104 *See* also requirements of J 108 to J 112.

Section 12

BOILER TUBES, PLAIN AND STAY, AND SUPERHEATER TUBES

1201 Where tubes are made of steel, the material is to comply with the relevant requirements of P 9.

1202 The following table gives the working pressures permissible with plain boiler tubes of standard thicknesses, whether of lapwelded wrought iron or of lapwelded or seamless mild steel :—

Outside diameter of tube in inches	Standard thicknesses in L. S. G.				Working pressures in lb. per square inch			
	A	B	C	D	A	B	C	D
2		11	10	9		155	215	300
$2\frac{1}{4}$	11	10	9	8	140	190	260	330
$2\frac{1}{2}$	11	10	9	8	125	175	230	300
$2\frac{3}{4}$	11	10	9	8	110	160	215	275
3	10	9	8	7	140	190	250	300
$3\frac{1}{4}$	10	9	8	7	130	180	230	280
$3\frac{1}{2}$	10	9	8	7	120	165	215	260

1203 On stay tubes, whether of wrought iron or of steel, a working stress of 7,500 lb. per square inch of the net sectional area at the bottom of the thread is allowed.

1204 The minimum thickness of stay tubes measured under the threads is to be $\frac{1}{4}$ inch for marginal stay tubes and $\frac{3}{16}$ inch for other stay tubes.

1205 Stay tubes are to be screwed at both ends with continuous threads, and the holes in the tube plates are to be tapped with continuous threads. The pitch of the thread is to be not finer than 10 threads per inch. It is desirable however that they should be screwed to the standard 9 threads per inch. The stay tubes are to be expanded by roller expanders and not made tight by caulking only.

1206 Nuts are not to be fitted to stay tubes at the combustion chamber end.

1207 If stay tubes are increased in thickness at the screwed ends so that the thickness at the bottom of thread is practically the same as in the body of the tube, the thickening is to be attained by upsetting and not by any welding process, and the tubes are to be annealed after the upsetting.

Tubes for Superheaters attached to Cylindrical Boilers

1208 The minimum thickness of the tubes is to be calculated by the following formula :—

$$t = \frac{WP \times d}{75} + 7$$

where WP = working pressure in the boiler, in lb. per square inch.
d = external diameter, in inches.
t = thickness, in 100ths of an inch.

Section 13

DISHED END PLATES WITHOUT STAYS

1301 For ends of boiler drums and receivers, crowns of vertical boilers and other similar plates dished to partially spherical form subject to pressure on the concave side, but not exposed to flame, and having no unreinforced opening greater than four times the thickness of the plate, the working pressure to be allowed is to be determined by the following formula or, if desired, by the formula in J 1605 :—

$$WP = \frac{480 \times S(T - \cdot 03)}{R}$$

where WP = working pressure, in lb. per square inch,
T = thickness of the end, in inches, after dishing but in no case to be less than the thickness of a seamless unpierced shell of the same diameter and material,
S = minimum tensile strength of the material in tons per square inch,
R = inside radius of curvature of end, in inches, which is not to exceed the outside diameter of drum end.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than $2\frac{1}{2}$ inches.

1302 Proposals to make dished end plates of semi-elliptic form will be considered provided full details are submitted before the work is commenced.

1303 Where the end is provided with a flanged manhole the thickness of the end in inches obtained by the formulæ in 1301 is to be increased by $\frac{1}{8}$ inch and the depth (F) of the manhole flange, measured in inches from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = required thickness of the end plate, in inches,
W = minor axis of the manhole, in inches.

1304 Where the end is provided with large openings for branches, mountings, or unflanged manholes the thickness of the end, as determined by the formulæ in 1301, is to be increased by $\frac{1}{8}$ inch and adequate compensation is to be provided, at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

1305 Where the end is provided with small openings greater than four times the thickness of the end plate, local compensation is to be provided.

1306 Where the end or crown is a complete hemisphere without stays or other supports, and is made in more than one plate, the working pressure to be allowed is given by the following formula :—

$$WP = \frac{(t - 2)\,S \times J}{C \times R}$$

where WP = working pressure, in lb. per square inch,
t = thickness of the plates, in 32nds of an inch,
S = minimum tensile strength of the steel plates, in tons per square inch,
J = strength of riveted joint as a percentage of the solid plate,
R = inner radius of curvature, in inches,
C = 2·83 for treble riveted,
2·9 for double riveted,
3·3 for single riveted.

WATER TUBE BOILERS

Section 14

GENERAL REQUIREMENTS

1401 In the design and construction of water tube boilers intended for working pressures up to 1,500 lb. per square inch the following conditions are to be observed.

Materials

1402 The materials are to comply with the relevant requirements of Chapter P.

Where it is proposed to use alloy steels for superheater headers or tubes, particulars of the appropriate British or other national standard material specifications with details of the chemical compositions, heat treatment and mechanical properties are to be submitted for consideration.

1403 Where the material does not conform to an established standard, particulars of the long-term creep and rupture data at the operating temperature are to be submitted in addition to the details required by 1402 for the purpose of assessing a safe working stress.

If the long-term creep data has been estimated, details of the method of estimation are also to be submitted.

Particulars of scaling and corrosion resistance of the material under the operating conditions are to be submitted when required.

Protection of Drums and Headers

1404 Where any parts of the boiler drums or headers are not protected by tubes and are exposed to radiation from the fire, or to the impact of hot gases, they are to be protected by a shield of good refractory materials or by other approved means.

Access Arrangements

1405 Manholes are to be provided in all drums of sufficient size to permit of access for internal examination and cleaning and for fitting and expanding the tubes. In the case of headers for water walls, superheaters or economisers and of drums which are too small to permit entry, sight holes or mud holes sufficiently large and numerous for these purposes are to be provided.

1406 Doors for manholes, mud holes and sight holes are to be formed from steel plate or of other approved construction and all jointing surfaces are to be machined.

The doors are to be of the internal type and are to be provided with spigots which have a clearance of not more than $\frac{1}{16}$ inch all round, i.e. the axes of the opening are not to exceed those of the door by more than $\frac{1}{8}$ inch.

1407 Doors for openings not larger than 9 inches × 7 inches need only be fitted with one stud which may be forged integral with the door. Larger doors are to be provided with two studs screwed through the door and fitted with nuts on the inside or alternatively, bolts may be used screwed through the door with the heads inside; other methods of attachment may be accepted provided details are submitted for consideration.

The crossbars or dogs are to be of steel.

For smaller circular openings in headers and similar fittings an approved type of plug may be used.

Section 15

CONSTRUCTION OF WATER TUBE BOILERS

Seamless Drums

1501 Seamless forged drums are to be made in accordance with the requirements of P 7.

Welded and Riveted Drums

1502 Drums of welded construction are to be made in accordance with the requirements of J 18 to J 23 in so far as they are applicable.

1503 Drums of riveted construction are to be made in accordance with the requirements of J 5. Where the internal diameters of the drums are less than 100 times the thickness of the plating at the seams, the type of longitudinal joints is to be such that the line of mean thickness of shell plating closely approximates to cylindrical form. Ordinary riveted lap joints are not considered suitable for this purpose.

1504 Drum shell plates are to be of cylindrical form and are to be bent entirely by machine; local heating and hammering is not to be employed. Where the plate is bent cold to an internal radius of less than 20 times the plate thickness it is to be efficiently heat treated after bending. Drum ends are to be made from one piece of rolled plate.

1505 All steel plates which are dished, flanged or locally heated are afterwards to be annealed or normalised.

For heat treatment of welded pressure vessels, *see* J 1925 to J 1929.

For plates which are hot formed, *see* P 310.

Thinning of Plates

1506 Where the tube plate is thicker than the drum shell plate, the tube plate, in way of the longitudinal and circumferential seams, is to be reduced in thickness by an equal amount on each side of the plate to the same thickness as the shell plate. This reduction in thickness is to be gradual and carried out by machining.

The thinning of dished end plates in way of buttwelded joints is also to be carried out by machining but may be made from one side of the plate.

Tube Holes

1507 The tube holes in drums or headers are to be formed in such a way that the tubes can be effectively tightened in them. Where the tube ends are not normal to the tube plates, there is to be a neck or belt of parallel seating of at least $\frac{1}{2}$ inch in depth measured in a plane through the axis of the tube at the holes. Where the tubes are practically normal to their plates, this parallel seating is to be not less than $\frac{3}{8}$ inch in depth.

Tube Ends

1508 Tubes are to be carefully fitted in the tube holes and secured by means of expanding and belling or by other approved methods. Tubes are to project through the neck or belt of parallel seating by at least $\frac{1}{4}$ inch and where they are secured from drawing out by means of bellmouthing only the included angle of belling is to be not less than 30°.

Hydraulic Tests

1509 In all new boilers working at pressures up to 100lb. per square inch the hydraulic test is to be twice the approved boiler pressure. For boilers working at pressures greater than 100lb. per square inch the hydraulic test pressure is to be 1·5 times the approved boiler pressure plus 50lb. per square inch.

1510 All boiler mountings are to be subjected to a hydraulic test of twice the approved boiler pressure with the exception of feed check valves and other mountings connected to the main feed system which are to be tested to 2·5 times the approved boiler pressure, or twice the maximum pressure which can be developed in the feed line in normal service, whichever is the greater.

Section 16

SCANTLINGS OF DRUMS, ENDS, HEADERS AND TUBES

Cylindrical Shells

1601 When plans of water tube boilers are submitted for approval particulars of the safety valves and their disposition on boiler and superheater, together with the estimated pressure drop through the superheater, are to be stated. The pressures proposed for the settings of boiler and superheater safety valves are to be indicated on the boiler plan.

1602 The thickness of drum shell plates, which are unpierced by tube holes, is to be determined by formula 1. Where, however, the thickness obtained by that formula exceeds 10 per cent of R then formula 2 is to be used. For shells with riveted joints *see* J 5.

$$(1) \qquad t = \frac{WP \times R \times 64}{C \times f} + 2$$

$$(2) \qquad t = \frac{WP \times R \times 64}{C \times f - WP} + 2$$

where t = thickness of plate, in 32nds of an inch,

WP = maximum working pressure, in lb. per square inch,

R = internal radius of the shell, in inches,

C is a coefficient having a value of

2 for seamless shells,

1·8 for fusion welded joints and

1·6 for forge welded joints.

f = nominal stress, in lb. per square inch.

For shells with metal temperatures up to and including 650° F., f is to be taken as $\frac{1}{4}$ of the specified minimum tensile strength of the material.

For seamless superheater drums and headers with metal temperatures above 650° F., the nominal stress f is to be taken from Table 1 which gives values for a number of wrought steels of approved composition in common use. Values of f for other steels will receive special consideration. (*See* J 1403.) When evaluating the stress f, the metal temperature is to be taken as not less than the maximum steam temperature plus 50° F. unless the headers are situated outside the boiler casing.

The temperature limitations indicated in Table 1 are maxima for the types of steel listed but are not necessarily acceptable for all steels of these types.

TABLE 1

MATERIAL		NOMINAL STRESS IN LB. PER SQUARE INCH AT FOLLOWING METAL TEMPERATURES IN °F.								
TYPE OF STEEL	Minimum tensile strength tons per sq. inch	650	700	750	800	850	900	950	1000	1050
Carbon and Carbon-manganese	24	13400	13200	12000	10500	8000	6000	—	—	—
	28	15700	15200	13400	11300	8600	6000	—	—	—
	32	17900	17200	14800	12100	9200	6000	—	—	—
	36	20200	19200	16200	12900	9600	6000	—	—	—
½% Mo.	26	14600	14600	14600	14200	13400	11000	6500	—	—
	31	17400	17400	17400	16600	15400	12000	6500	—	—
1% Cr. ½% Mo.	27	15100	15100	15100	14800	13800	11500	7800	4800	2800
	31	17400	17400	17400	16800	15600	12500	8000	4800	2800
2¼% Cr. 1% Mo.	27	15100	15100	15100	14800	13800	11500	7800	6000	4600

Tube Plates

1603 The thickness of drum tube plates and cylindrical headers which are drilled for tubes is to be determined by the following formula:—

$$t = \frac{WP \times R \times 64}{1{\cdot}8 \times f \times E - WP} + 2$$

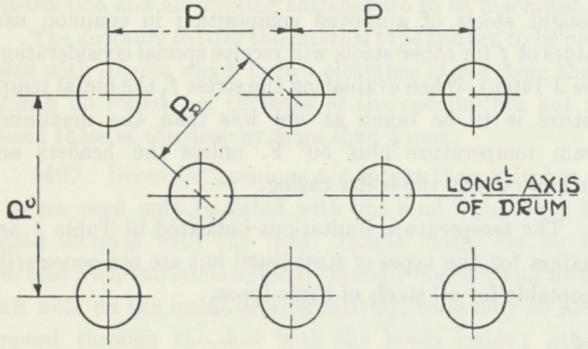
where t, WP and f are as defined in 1602,

R = internal radius of tube plate, in inches,

E = efficiency of ligaments between tube holes expressed as a fraction and calculated in accordance with 1604.

Ligament Efficiency

1604 Where tube plates or header shells are drilled for tubes the ligament efficiency between tube holes shall be determined by the following methods and the lowest value obtained shall be used in the formula of 1603 for tube plate thickness. Method 2 is only applicable where the tube holes are arranged in lines parallel to the axis so as to form a staggered arrangement with diagonal ligaments.



(1) $E = \frac{P - d}{P}$

(2) $E = \frac{3{\cdot}84 P_D (P_D - {\cdot}95d)^2}{(P^2 + {\cdot}5 P_C{}^2)(P_D - {\cdot}95d) + P \times P_C \times {\cdot}375d}$

where E = ligament efficiency, expressed as a fraction,

P = longitudinal pitch of tube holes, in inches,

P_C = circumferential pitch of tube holes, in inches, in line circumferentially measured at the mid-thickness of the plate,

P_D = diagonal pitch of tube holes, in inches, measured at the mid-thickness of the plate,

d = mean effective diameter of tube holes, in inches.

The circumferential pitch P_C is to be such that the circumferential ligament efficiency is equal to or greater than half the ligament efficiency on the longitudinal axis.

Dished End Plates

1605 Where drum ends for boilers and headers are dished from plates and are subject to pressure on the concave side they are to comply with the following :—

(*a*) For ends dished to partial spherical form the inside radius of dishing, R, is to be not greater than the outside diameter D.

The inside corner radius, r, is to be not less than four times the plate thickness and in no case less than $2\frac{1}{2}$ inches.

The corner radius at the manhole flange is to be not less than 1 inch.

(*b*) For ends having no unreinforced opening greater than four times the plate thickness, or $2\frac{1}{2}$ inches, whichever is less, the working pressure to be allowed is to be determined by the following formula:—

$$WP = \frac{(T - 1) \times f \times h}{3{\cdot}8 \times D^2} \times \left\{ \frac{\frac{r}{R} + {\cdot}05}{\frac{r}{R} + {\cdot}15} \right\}$$

where WP = working pressure, in lb. per square inch,

T = thickness of the end, in 32nds of an inch, after dishing which in no case is to be less than the thickness of an unpierced shell of the same diameter and material,

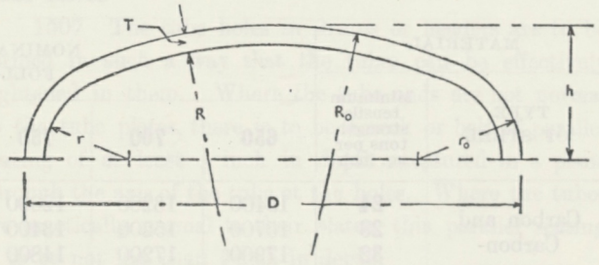
f = nominal stress, in lb. per square inch, having values as stated in 1602,

D = outside diameter of end, in inches,

R = inside radius of dishing, in inches,

r = inside radius of corner, in inches,

h = external height of dishing, in inches, measured from the centre of the corner radius, which is to be calculated as follows:—



$$h = R_o - \sqrt{\left(R_o - \frac{D}{2}\right)\left(R_o + \frac{D}{2} - 2r_o\right)},$$

R_o = outside radius of dishing, in inches,

r_o = outside radius of corner, in inches.

1606 Proposals to make dished ends of semi-ellipsoidal form will be considered provided details are submitted before the work is commenced.

Flat End Plates

1607 For unstayed flat end plates attached by one of the methods shown in J 18, Fig. 2 the working pressure is to be determined by the following formula :—

$$WP = \frac{(t-1)^2 \times f}{150 \times D^2}$$

where WP = working pressure, in lb. per square inch,
t = thickness of plate, in 32nds of an inch,
f = nominal stress, in lb. per square inch, having values as stated in 1602,
D = inside diameter in inches.

Compensation for Openings

1608 Where a dished end is provided with large openings for branches, mountings or unflanged manholes, the thickness of the end as determined by the formula in 1605 is to be increased by $\frac{1}{8}$ inch and adequate compensation is to be provided at least equivalent to the cross sectional area obtained by multiplying the diameter or major axis of the opening cut in the end plate by the thickness required for an equivalent unpierced end.

1609 Where a dished end is provided with a flanged manhole the thickness of the end obtained by the formula in 1605 is to be increased by at least 15 per cent but in no case less than $\frac{1}{8}$ inch and the depth of the manhole flange is to be determined as follows :—

$$F = \sqrt{T_1 \times W}$$

where F = depth of manhole flange, in inches, measured from the outer surface at the minor axis,
T_1 = required thickness of end plate, in inches,
W = minor axis of manhole, in inches.

1610 In the case of flat plates, the depth of the manhole flange measured from the outer surface is to be not less than $\sqrt{T \times W}$, where T is the thickness of the plate in inches and W is the minor axis of the hole in inches.

1611 Manholes in cylindrical shells are to have their shorter axes arranged longitudinally, and are to be located clear of the welded joints in the shell. Where the cylindrical shell is cut for a manhole, compensation is to be provided in accordance with 1612.

1612 Compensation is to be provided for all openings in shell plates if the diameters of such openings exceed 2·5 times the thickness of the shell plus $2\frac{3}{4}$ inches or $\frac{D}{6}$ whichever is less, where D is the internal diameter of the cylindrical shell in inches.

The compensation provided is to be sufficient to ensure that the strength in way of the opening is not less than that of a seamless shell. For thicknesses of seamless shells *see* formula of 1602.

The width of reinforcing rings allowable for compensation is to be taken as $\sqrt{D \times T}$ or $\frac{D}{2}$ whichever is less, where D is the diameter of the opening in inches and T is the shell plate thickness in inches. If the surplus thickness of shell plate above that required for a seamless shell is included as compensation, the width allowable for this purpose is the same as that for compensating rings.

Where standpipes are welded to the shell the surplus thickness of the standpipe above that required to withstand the internal pressure may be included as compensation for a distance of $\sqrt{d \times t}$ from the plate surfaces where d and t in inches are the internal diameter and wall thickness of the standpipe respectively. The surplus thickness is to be taken as the difference in thickness proposed for the standpipes and that required by E 512 for a steampipe of the same bore and material.

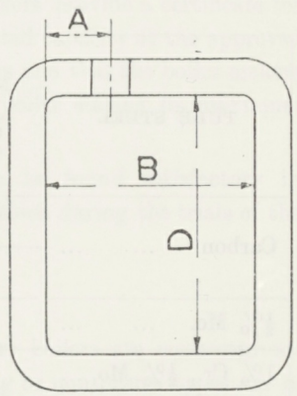
The sectional area of welds which attach compensating rings and standpipes to cylindrical shells may be included as compensation.

Headers of Rectangular Section

1613 The working pressure to be allowed for solid drawn and forged headers of rectangular section is to be determined by the following formulæ (1) and (2) whichever gives the lower pressure :—

(1) $$WP = \frac{4 \times f}{\left(\frac{B}{t}\right)^2 + \frac{D}{t}}$$

(2) $$WP = \frac{2 \times f \times E}{K \times \left(\frac{B}{t}\right)^2 + \frac{D}{2 \times t}}$$



where WP = maximum working pressure, in lb. per square inch,
f = nominal stress, in lb. per square inch, having values as stated in 1602,
t = wall thickness, in inches, minus 0·06 inch,

B = internal length, in inches, of the side under consideration,

D = internal length, in inches, of supporting side, at right angles to dimension B,

E = minimum longitudinal efficiency of ligament between tube holes or hand holes, expressed as a fraction,

K is a coefficient having values dependent on the ratio of $\frac{A}{B}$ and is to be calculated as follows:—

$$K = 3\left[\frac{A}{B} - \left(\frac{A}{B}\right)^2 - \frac{1}{6}\right]$$

NOTE.—K as calculated may be $\pm$ but the numerical value only is to be taken for use in formula 2.

A = distance between centre line of tube holes or hand holes and the nearest supporting side, in inches; where there is more than one row of tube holes in the length B, the value of A which gives a maximum K is to be selected.

Cross-reference

1614 For details of hand holes and doors, *see* J 1405 to J 1407.

For details of tube holes and fitting of tubes, *see* J 1507 and J 1508.

Tubes

1615 The minimum thickness of tubes is to be determined by the following formulæ:—

For all boiler and economiser tubes:—

$$t = \frac{WP \times d}{10 \times S} + 1{\cdot}5\,d + 4$$

For superheater tubes:—

$$t = \frac{WP \times d}{K} + 6$$

where WP = working pressure in the boiler, in lb. per square inch,

d = external diameter, in inches,

S = minimum tensile strength of the tube material, in tons per square inch,

t = thickness, in 100ths of an inch.

K is a coefficient given in Table 2.

The estimated metal temperature of the superheater tubes is to be stated when plans are submitted for approval but in no case is a temperature less than the maximum steam temperature plus 50° F. to be taken when evaluating K. For temperatures intermediate between those listed in the table and for carbon steels with tensile strengths intermediate between 20 and 28 tons per square inch, the values of K may be obtained by interpolation.

TABLE 2

TUBE STEEL	Minimum tensile strength tons per sq. inch	SUPERHEATER TUBES—VALUE OF COEFFICIENT K AT FOLLOWING METAL TEMPERATURES IN °F.											
		650	700	750	800	850	900	950	1000	1050	1100	1150	1200
Carbon	20	200	192	180	160	136	110	—	—	—	—	—	—
	28	280	260	240	200	160	110	—	—	—	—	—	—
½% Mo.	25	250	250	250	250	250	220	160	—	—	—	—	—
1% Cr., ½% Mo. ...	27	270	270	270	270	270	230	200	140	90	—	—	—
2¼% Cr., 1% Mo....	27	270	270	270	270	270	250	220	180	140	—	—	—
18% Cr., 12% Ni., 1% Nb.	35	280	278	276	274	272	270	267	264	260	200	140	100

NOTE: For 18% Cr., 12% Ni., 1% Nb. material, the Niobium content is not to be less than 10 times the Carbon content.

The thicknesses derived from these formulæ are minima and further provision is to be made for minus tolerances where necessary.

Where it is proposed to use other alloy steels for superheater tubes, particulars are to be submitted for special consideration in accordance with J 1402.

The formula for boiler tubes does not provide for adverse corrosion conditions and boiler tubes intended for low pressure boilers of 250 lb. per square inch working pressure and under with open feed systems are to be made one gauge thicker than required by the formula.

1616 The thickness of downcomer tubes and pipes which form an integral part of the boiler and which are not exposed to combustion gases is to comply with the Rules for steam pipes.

Standpipes

1617 Where standpipes and branches are attached to drums or headers by means of welding or by screwing and seal welding the minimum wall thickness for metal temperatures up to 650° F. is to be determined by the following formula but in no case is to be less than $\frac{1}{4}$ inch:—

$$t = 1{\cdot}4D + 6$$

where t = thickness of standpipe or branch, in 32nds of an inch,

D = nominal bore, in inches.

For metal temperatures above 650° F. the wall thickness is to be not less than that required by the above formula or by the formula for shells in 1602, whichever is the greater.

1618 Every flange is to have a fillet with a radius not less than the thickness of the neck to which it is attached.

Section 17

BOILER MOUNTINGS AND FITTINGS FOR WATER TUBE BOILERS

Safety Valves

1701 The safety valves in number, area and design are to be in accordance with the requirements of J 403 to J 411, and are to be so disposed and proportioned that the superheater will be protected from overheating in all normal circumstances.

Waste Steam Pipe

1702 The waste steam pipe and passages leading to it from the safety valves are to be in accordance with the requirements of J 411.

Safety Valve Settings

1703 All boiler and superheater safety valves are to be set under steam to their respective working pressures which are to be not greater than 3 per cent above the pressure for which the boiler is approved. In the setting of superheater safety valves, allowance is to be made for the pressure drop through the superheater so that under discharge conditions the pressure in the boiler will not exceed the approved boiler pressure.

In no case shall the superheater safety valve setting exceed by more than 3 per cent the pressure for which the steam piping and shafting are approved.

Accumulation Tests

1704 Tests for accumulation of pressure are to be carried out with the stop valve closed and under full firing conditions for a period not exceeding 7 minutes. The accumulation is not to exceed 10 per cent of the working pressure.

Where accumulation tests might endanger the superheaters, consideration will be given in cases of oil fired boilers to the omission of these tests, provided that application is made when the boiler plan and sizes of safety valves are submitted for approval, and that the safety valves are of an approved type for which the capacity has been established by test in the presence of the Surveyors or an approved independent authority, or for which the Society is satisfied, by long experience of accumulation tests, that the capacity is adequate.

When it is agreed to waive accumulation tests it will be required that the valve makers provide a certificate for each safety valve, stating its rated capacity at the approved working conditions of the boilers and that the boiler makers provide a certificate for each boiler stating its maximum evaporation.

The safety valves are to be found satisfactory in operation under working conditions during the trials of the machinery on board ship.

Stop Valves

1705 Where two or more boilers are connected together, stop valves of self-closing or non-return types are to be fitted.

Water Level Indicators

1706 Every boiler is to be fitted with at least two independent means of indicating the water level in it, one of which is to be a glass water gauge.

The other means is to be either an additional glass water gauge or an approved equivalent device other than test cocks, but where a steam and water drum exceeding 13 feet in length is fitted athwartships, two glass water gauges are to be fitted in suitable positions, one near each end of the drum.

1707 The position of the glass water gauges of boilers in which the tubes are entirely drowned when cold is to be such that water is just showing in the glass when the water level in the steam drum is just above the top of the uppermost tubes when the boiler is cold. In boilers, the tubes of which are not entirely drowned when cold, the glass water gauges are to be placed, to the Surveyor's satisfaction, in the positions which have been found by experience to indicate satisfactorily that the water content is sufficient for safety when the boiler is worked under all service conditions.

Feed Check Valves and Water Level Regulators

1708 Two feed check valves, connected to separate feed lines, are to be provided for each boiler and are to be attached, wherever practicable, direct to the boiler or to an economiser which forms an integral part of the boiler.

Where, however, the arrangements necessitate the use of a common inlet pipe on the economiser for both main and auxiliary feed systems, this pipe is to be as short as practicable and the arrangement of check valves is to be such that either feed line can be effectively isolated without interruption of the feed water supply to the boiler.

At least one of the feed water systems is to be fitted with an approved feed water regulator whereby the water level in the boilers is controlled automatically. (*See* E 7 for arrangements and details of boiler feed systems.)

1709 The feed check valves are to be fitted with efficient gearing, whereby they can be satisfactorily worked from the stokehold floor, or other convenient position.

1710 Standpipes on boilers, for feed inlets, are to be designed with an internal pipe to prevent direct contact between the feed pipe and the boiler shell or end plates with the object of minimizing thermal stresses in these plates.

Similar arrangements are to be provided for desuperheater and other connections where significant temperature differences occur in service.

Mountings and Fittings

1711 Mountings and fittings not mentioned in this Section are to be in accordance with the requirements of J 4.

WELDED PRESSURE VESSELS

For list of manufacturers of Class 1 Welded Pressure Vessels see appendix to this Chapter.

Section 18

General

1801 The requirements of Sections 18 to 24, except where otherwise stated, are applicable to boilers, air receivers, heat exchangers and other pressure vessels of fusion welded construction intended for marine services, but excluding vessels containing radioactive materials or gases.

1802 The term "fusion weld" is, for the purpose of these requirements, applicable to welded joints made by the metal arc process with covered electrodes or other electric arc process in which the arc stream and the deposited metal are shielded from atmospheric contamination. The welding may be done by hand or by machine.

Materials

1803 Materials used in the construction of welded pressure vessels are to be of weldable quality steel and are to be manufactured and tested in accordance with the relevant requirements of Chapter P.

The tensile strengths of mild steel pipes, forgings and castings are not to exceed 35 tons per square inch. The tensile strengths of carbon and carbon-manganese steel plates are to be within the range of 24 to 38 tons per square inch subject to the limitation of application of P 307.

1804 Where it is proposed to use alloy or other steels not covered in Chapter P, specifications detailing the mechanical properties, chemical composition and heat treatment are to be submitted for special consideration. As the strengths of such steels are sensitive to heat treatment, check tensile tests after hot forming, normalising, and stress relieving at the fabrication works will, in general, be required.

1805 All steels for Class 1 vessels are to be killed (*see* P 307); steels for Classes 2 and 3 vessels may be killed or semi-killed. All these steels are to contain not more than 0·05 per cent sulphur and 0·05 per cent phosphorus.

Plans

1806 Plans in triplicate, showing full constructional features of the vessel and dimensional details of the weld grooves for longitudinal and circumferential seams and attachments, together with particulars of the electrodes and of the mechanical properties of the materials are to be submitted before construction is commenced.

Electrodes

1807 Where a pressure vessel is to be made of alloy steel and where the scantlings have been approved on the basis of the high temperature properties of the material, particulars of the electrodes to be used including typical mechanical properties and chemical composition of the deposited weld metal are to be submitted for approval.

Particulars of typical creep, rupture and ductility properties of the deposited weld metal at elevated temperatures are also to be submitted when required.

Classification of Fusion Welded Pressure Vessels

1808 For Rule purposes pressure vessels are graded as follows:—

Class 1

Pressure parts of boilers and fired pressure vessels intended for working pressures above 50 lb. per square inch. Pressure parts of steam heated steam generators where the working pressure exceeds 165 lb. per square inch, or where the working pressure in lb. per square inch multiplied by the internal diameter of the shell in inches exceeds 8,250.

Other pressure vessels where the shell thickness exceeds $1\frac{1}{2}$ inches.

Class 2

Pressure parts of boilers and fired pressure vessels not included in Class 1.

Pressure parts of steam heated steam generators not included in Class 1.

Other pressure vessels where the working pressure exceeds 250 lb. per square inch, or the metal temperature exceeds 300° F., or where the working pressure in lb. per square inch multiplied by the actual thickness of the shell in inches exceeds 90.

Maximum shell thickness $1\frac{1}{2}$ inches.

Class 3

Vessels not included in Classes 1 and 2.

Maximum shell thickness $\frac{5}{8}$ inch.

1809 In special circumstances relating to service conditions, materials, operating temperature, the carriage of dangerous gases and liquids, etc., it may be necessary to include other pressure vessels in the Class 1 category.

1810 All Class 1 vessels are required to be heat treated. Certain Class 2 vessels, as described in the following paragraph, are required to be heat treated and are graded as Class 2A. Other Class 2 vessels, graded as Class 2B, and all Class 3 vessels are not required to be heat treated.

Pressure parts of boilers, fired pressure vessels and steam heated steam generators in Class 2 category are required to be heat treated. Other vessels in Class 2 are required to be heat treated where the shell thickness in inches exceeds $\frac{D}{130} + 0{\cdot}4$ or $1\frac{1}{4}$ inches whichever is the smaller where D=internal diameter of vessel in inches.

For heat treatment of pressure vessels *see* J 1925 to J 1929.

1811 Vessels which are required to comply with Classes 2 or 3 standards will, if manufactured in accordance with the requirements for a superior class, be approved with the scantlings appropriate to that class.

1812 The conditions of manufacture and test for the three classes are given in the following Table 3. It is required that Class 1 vessels be constructed by firms whose names are included in the list of firms recognised by the Committee for the manufacture of Class 1 fusion welded pressure vessels.

Table 3

Class	Radiographic examination	Heat Treatment	Routine Weld Tests	Hydraulic Tests
1	required	required	required	required
2A	—	required	required	required
2B	—	—	required	required
3	—	—	—	required

Scantlings of Welded Pressure Vessels

1813 For the scantlings of shell and ends of cylindrical boilers, water tube boilers and air receivers see the relevant sections of this chapter.

Joints

1814 Longitudinal joints for all classes of vessels are to be butt joints. Circumferential joints for Class 1 vessels are to be butt joints and for Class 2 and 3 vessels may be either butt joints or lap joints.

Cylindrical Shells

1815 For pressure vessels operating at metal temperatures of 650° F. and under the thickness of cylindrical shells is to be determined by the following formula, but no plate is to be less than $\frac{3}{16}$ inch thick.

$$WP = \frac{K \times S}{D}(T - \cdot 06) \qquad T = \frac{WP \times D}{K \times S} + \cdot 06$$

where WP is the working pressure in lb. per square inch,

T is the thickness of the shell plate in inches,

S is the minimum tensile strength in tons per square inch,

D is the internal diameter of the cylindrical shell in inches,

K = 1,008 for Class 1 vessels,
= 886 for Class 2A vessels,
= 832 for Class 2B vessels,
= 662 for Class 3 vessels.

1816 For pressure vessels operating at metal temperatures exceeding 650° F. the thickness of cylindrical shells is to be determined by the appropriate formula of J 1602 in association with the permissible stresses at temperature of Table 1. For Class 2A vessels C is to be taken as 1·6 and for Class 2B as 1·5.

Dished End Plates

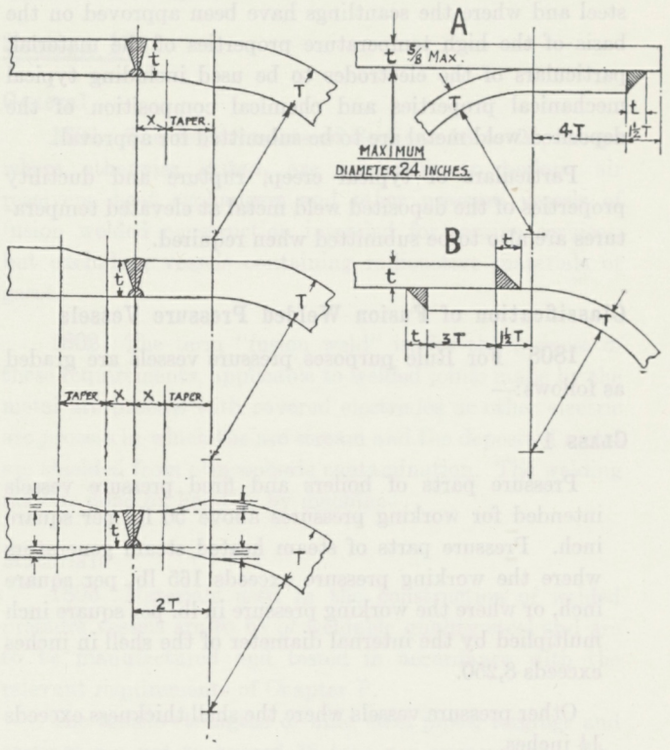
1817 The scantlings of dished ends for Classes 1, 2 and 3 pressure vessels subject to pressure on the concave side but not exposed to flame are to be determined by the requirements of J 1605, J 1606, J 1608 and J 1609.

1818 The scantlings of dished ends for Class 3 pressure vessels subject to pressure on the convex side are to be determined by the formula in J 2404.

1819 For typical acceptable methods of attaching dished ends to cylindrical shells and for limitations of different types *see* Fig. 1. Types A and B are to be made a tight fit in the cylindrical shell. (*See* J 2206).

Parallel portions marked × of about $1\frac{1}{4}$ inches are to be provided for Class 1 pressure vessels to facilitate the radiographic examination of the welds. The thickness t of the parallel portions is to be not less than that of an unpierced cylindrical shell of seamless or welded construction, whichever is applicable. The taper on each side of the plates is to be not greater than 1 in 4.

Fig. 1 Typical Acceptable Methods of Attaching Dished End Plates to Cylindrical Shells



Type	Acceptable for
A	Class 3 pressure vessels
B	Class 2 and 3 pressure vessels
Others	Class 1, 2 and 3 pressure vessels

Flat End Plates

1820 The scantlings of flat end plates for Classes 1, 2 and 3 pressure vessels are to be determined by the formula in J 1607.

1821 For typical acceptable methods of attaching flat ends to small cylindrical shells and for application of different types *see* Fig. 2.

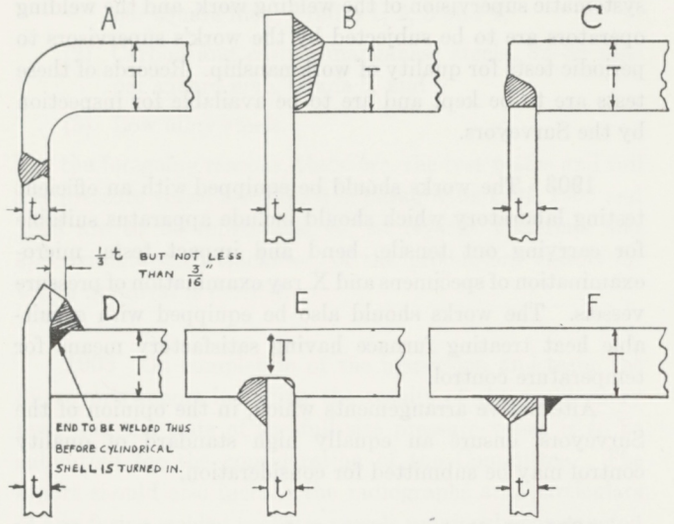
Standpipes

1822 The scantlings of standpipes are to be determined by the requirements of J 1617.

For acceptable methods of attaching flanges to standpipes and service limitations of the various types *see* Fig. 3.

Where flanges are secured by screwing, the branch and flange are to be screwed with a vanishing thread, and the diameter of the screwed portion of the branch over the thread is to be not less than the outside diameter of the unscrewed branch.

FIG. 2 TYPICAL ACCEPTABLE METHODS OF ATTACHING UNSTAYED FLAT END PLATES TO SMALL PRESSURE VESSELS, CIRCULAR AND SQUARE HEADERS AND HEAT EXCHANGERS



NOTE:—Ends, Types A, B and C are to be used for Headers

After the flange has been screwed hard home the branch is to be expanded into the flange.

The vanishing thread on a branch is to be not less than three pitches in length and the diameter at the root of the thread is to increase uniformly from the standard root diameter to the diameter at the top of the thread. This may be produced by suitably grinding the dies, and the flange should be tapered out to the same formation.

Attachment of Standpipes, Branches, Compensating Plates and Pads

1823 Compensating plates and pads are to be bedded closely to the surface to which they are to be welded, and compensating plates are to be provided with a tell-tale hole not greater than $\frac{3}{8}$ inch in diameter open to the atmosphere.

For acceptable methods of attaching standpipes, branches, compensating plates and pads *see* Fig. 4.

Alternative methods of attachment may be accepted provided details are submitted for consideration.

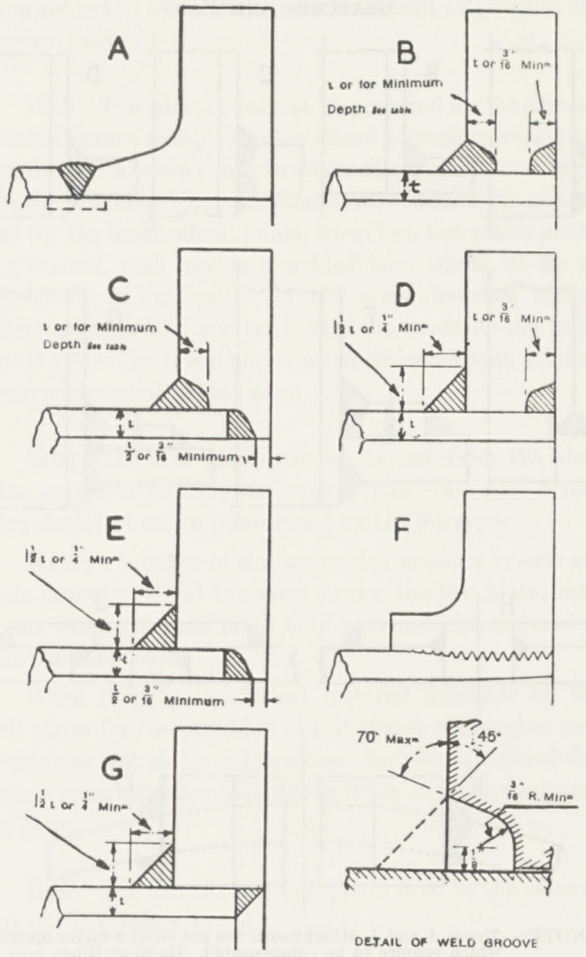
Access Arrangements

1824 Manhole, inspection and cleaning openings and doors for cylindrical boilers, watertube boilers and air receivers are to be in accordance with the relevant sections of this chapter.

Cross-reference

1825 For compensation for openings, *see* J 1608 to J 1612.

FIG. 3 ACCEPTABLE METHODS OF ATTACHING FLANGES TO STEEL BRANCHES OR STANDPIPES.

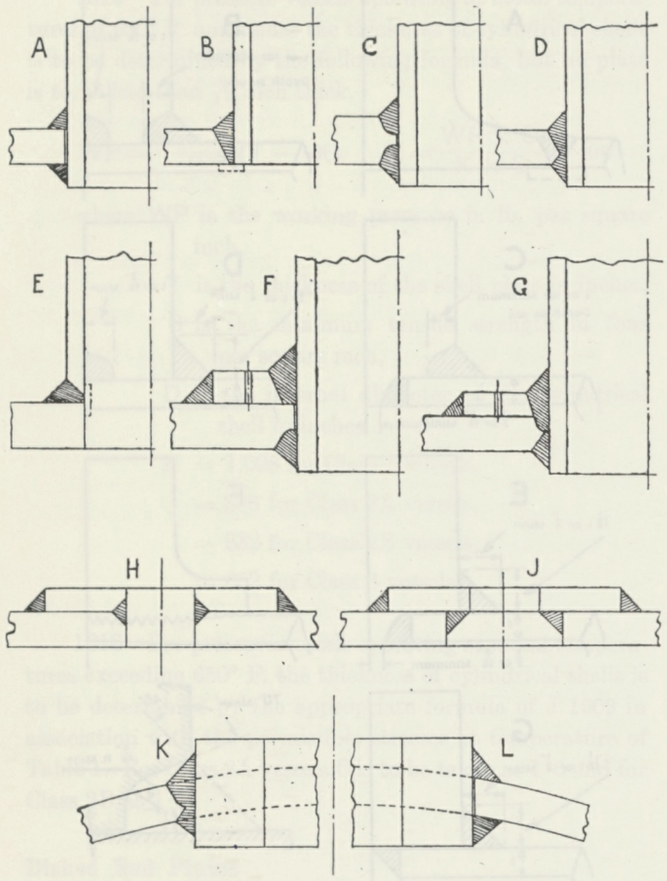


Pipe Bore	Minimum Depth of Groove for flanges B and C
$\frac{1}{2}$" and $\frac{3}{4}$"	$\frac{1}{4}$"
1" to 1$\frac{1}{2}$"	$\frac{5}{16}$"
2" and over	$\frac{3}{8}$"

TABLE 3

Type of Flange Attachment	Service and Rating			
	Feed, Air, Oil Fuel and other fluids		Steam	
	Pressure lb. per sq. in.	Temperature °F.	Pressure lb. per sq. in.	Temperature °F.
A	All Conditions		All Conditions	
B & C	All Conditions		750	850
D & E	750	500	550	750
F	600		450	
G	250		250	500

FIG. 4 TYPICAL ACCEPTABLE METHODS OF ATTACHING BRANCHES AND PADS



NOTE:—Types A and L attachments are not to be used for openings which require to be compensated. Backing Rings may be used with Types B and E.

Section 19

REQUIREMENTS FOR CLASS 1 FUSION WELDING

1901 In order that the name of a firm may be included in the list of firms recognised by the Committee for the manufacture of Class 1 fusion welded pressure vessels, it will be necessary for the Surveyors to visit the firm's works for the purpose of inspecting the welding plant, equipment and procedure and to arrange for the carrying out of preliminary tests and the survey during construction and testing of a full size welded pressure vessel as stated in 1904, 1905 and 1906.

1902 The welding plant and equipment are to be suitable for undertaking work of the standard required for Class 1 welding and are to be maintained in an efficient working condition. The welding apparatus is to be installed under cover and so arranged that the welding work is carried out in positions free from draughts and adverse weather conditions. The procedure should include the regular and systematic supervision of the welding work, and the welding operators are to be subjected by the work's supervisors to periodic tests for quality of workmanship. Records of these tests are to be kept and are to be available for inspection by the Surveyors.

1903 The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, micro-examination of specimens and X ray examination of pressure vessels. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control.

Alternative arrangements which, in the opinion of the Surveyors, ensure an equally high standard of quality control may be submitted for consideration.

1904 Preliminary tests to demonstrate the quality of the welding work are to be carried out by the firm on specimens cut from test plates welded under the supervision of the Surveyors. The test plates are to comply with 1907, but are to be at least $\frac{3}{4}$ inch thick. The welded seams of the test plates are to be radiographed. The Surveyors are to select portions of the test plates containing the welded joint from which specimens are to be provided for the following:—

(1) Tensile, bend, impact, hardness and fatigue tests.
(2) Micrographs at 100 and 300 magnifications, of weld centre, fusion zone and parent plate.
(3) Macrograph of full section of weld.
(4) Chemical analysis of deposited weld metal.
(5) Chemical analysis of test plates.

As an alternative to (5), a guaranteed analysis obtained from the steel makers will be accepted.

1905 For the fatigue tests, not less than four test pieces, cut transversely to the welded seam, should be used and progressively loaded to determine the fatigue strength.

1906 A full size pressure vessel is to be constructed in accordance with the requirements of these Rules for Class 1 fusion welded pressure vessels under the supervision of the Surveyors.

1907 The recognition of works for the manufacture of Class 1 welded pressure vessels will be limited to the grade of vessel which has been the subject of test in obtaining

recognition. Grading will be governed by shell thickness at the welded joint and by the quality of the steel. For grading purposes steels will be grouped in three categories, namely,

(1) Carbon and carbon-manganese steels, 24–34 tons per square inch, Grades 1, 2, 3 and 4,

(2) Carbon and carbon-manganese steels, 32–38 tons per square inch, Grade 5, and

(3) Low alloy steels.

For the foregoing reasons, therefore, the test plates and full size pressure vessel mentioned in paragraphs 1904, 1905 and 1906 are to be representative, as regards materials and approximate shell thickness, of the production vessels for which approval is desired.

1908 On completion of the inspection and tests, the Surveyor's report including the results of the preliminary tests and the tests of the full size pressure vessel is to be submitted for the consideration of the Committee. The report should also include the radiographs and particulars of any fusion welded pressure vessels previously constructed by the firm.

1909 Following the recognition of firms for the manufacture of Class 1 fusion welded pressure vessels, the Surveyors should report periodically to the Committee on the conditions which obtain at the works and if considered necessary carry out further tests.

1910 If subsequent to being placed on the Class 1 list a firm intends to manufacture pressure vessels either of a different grade, or by means of a different welding process than used in the construction of the full size vessel on which the original approval of the works was based, a series of procedure tests may be required before recognition is extended to cover the new conditions of manufacture. In the first instance, however, particulars and plans showing full details of the proposed vessel or new welding process are to be submitted, when the necessity for procedure tests will receive consideration.

Routine Tests for Class 1 Fusion Welded Pressure Vessels

1911 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported, during welding, that warping is reduced to a minimum.

1912 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

1913 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints, when two test plates are to be prepared, each having a welded joint which, so far as possible, is a duplication of the circumferential seams. Where a number of similar vessels are made at the same time it will suffice if test plates are provided for each 100 feet of circumferential welded seam.

1914 The test plates are to be cut from the shell plate or plates forming the appropriate seam and before being detached are to be stamped by the Surveyor.

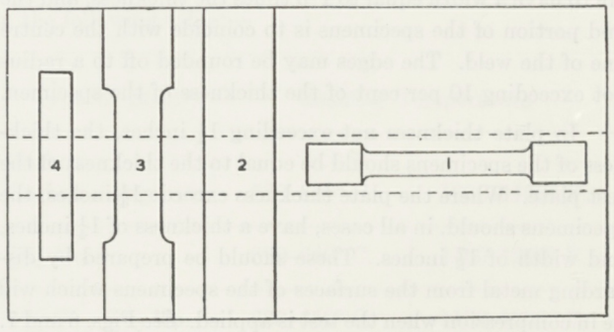
Where a number of similar welded pressure vessels are made concurrently at the same works, the test plates may be cut from one shell plate only provided the material is from the same cast.

When there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate provided this plate is from the same cast and in the same heat treatment condition.

1915 The thickness of test plates is to be the same as that of the pressure vessel.

1916 One test plate is to be cut up into test specimens as shown in Fig. 5 and Fig. 10. All specimens are to be cut from a plate of suitable length and are to comply with the test requirements detailed in 1918 to 1922.

FIG. 5



(1) Tensile, all weld metal. (3) Tensile (joint).

(2) Bend. (4) Marco.

Retests

1917 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test for all Weld Metal. Specimen No. 1

1918 The diameter of the all weld metal test piece at the reduced parallel portion is to be not less than 0·564 inch, except in the case of thin plates where the largest practicable diameter should be used.

Diameter of test piece inches	Gauge length inches	Cross Sectional Area Square inches
·798	2·82	0·50
·564	2·0	0·25
·505	1·79	0·20
·479	1·70	0·18
·452	1·60	0·16
·437	1·55	0·15
·424	1·50	0·141
·399	1·41	0·125
·357	1·26	0·100

The tensile strength of the weld metal is to be not less than the minimum and not more than 10 tons per square inch above the minimum specified for the plate.

Minimum elongation on gauge length = 20 per cent.

Minimum reduction of area = 35 per cent.

Transverse Bend Test. Specimen No. 2

1919 Two bend test specimens of rectangular section are to be cut from the test plate, one to be bent with the outer surface of the weld in tension, and the other with the inner surface in tension.

The specimens are to be cut transversely to the weld and are to have a width equal to 1·5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. The edges may be rounded off to a radius not exceeding 10 per cent of the thickness of the specimen.

In plate thickness not exceeding $1\frac{1}{4}$ inches, the thickness of the specimens should be equal to the thickness of the test plate. Where the plate thickness exceeds $1\frac{1}{4}$ inches, the specimens should, in all cases, have a thickness of $1\frac{1}{4}$ inches, and width of $1\frac{7}{8}$ inches. These should be prepared by discarding metal from the surfaces of the specimens which will be in compression when the test is applied. *See* Figs. 6 and 7.

Where the thickness of the plate permits, the bend specimens may be prepared as shown in Fig. 8.

For each specimen the weld reinforcement should be removed by buffing or machining so that the outer and inner surfaces of the weld are flush with the surface of the plate.

Each specimen is to be bent cold without fracture through an angle of 180 degrees, over a former having diameter not greater than three times the thickness of the specimen. The distance between supports should be not more than 5·2 times the thickness of the specimen.

FIG. 6 NORMAL BEND SPECIMEN

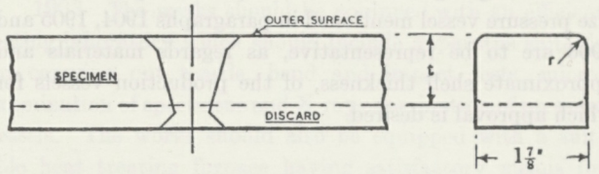


FIG. 7 REVERSE BEND SPECIMEN

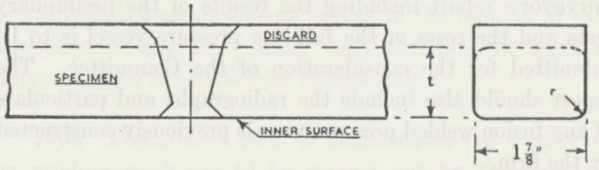
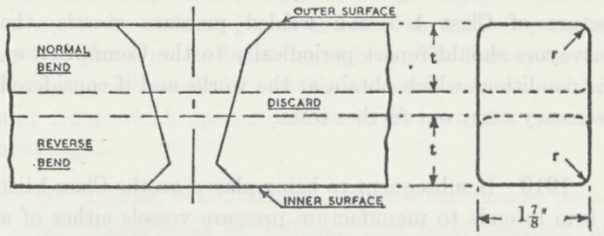


FIG. 8 NORMAL AND REVERSE BEND SPECIMENS CUT FROM SINGLE PIECE OF PLATE



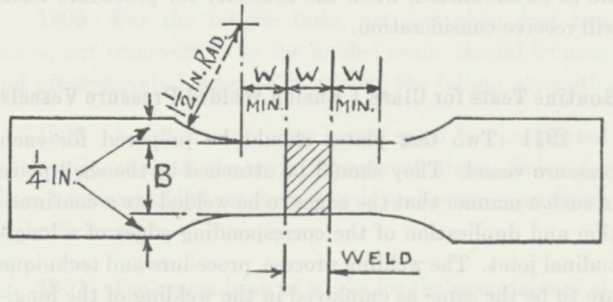
t = thickness of the specimen which is the thickness of the plate or $1\frac{1}{4}$ inches, whichever is the lesser.

r = corner radii not exceeding ·1t.

NOTE:—Where t is less than $1\frac{1}{4}$ inches the width of the specimen is to be 1·5t.

Tensile Test for Joint. Specimen No. 3

1920 FIG. 9



B = Not less than thickness of plate with a minimum width of $1\frac{1}{2}$ inches.

An equivalent form of test piece to that shown in Fig. 9 may be accepted.

The weld is to be machined flush with plates on both sides.

The ultimate tensile strength is to be not less than the minimum specified for the plate. If the test piece breaks in the plate or fusion zone at not less than 95% of the minimum specified for the plate the test may be accepted.

Macro Specimen. Specimen No. 4

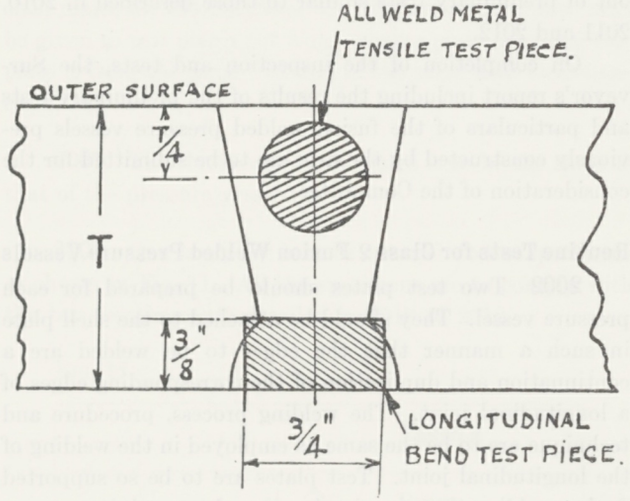
1921 The specimen is to be etched across the full section of the weld, and examined by the Surveyor.

Longitudinal Bend Test

1922 Where the plate thickness exceeds $1\frac{1}{2}$ inches a longitudinal all-weld metal bend test piece is required. The test piece may be prepared from the same material as used for the all-weld metal tensile test, as shown in Fig. 10, and is to be $\frac{3}{4}$ inch wide by $\frac{3}{8}$ inch thick cut parallel to the seam. The sharp edges of the test piece may be slightly rounded off before bending.

The test piece is to be bent cold through an angle of 90 degrees over a former of $1\frac{1}{8}$ inches diameter without fractures appearing on the tension surface.

FIG. 10 LONGITUDINAL BEND TEST



Radiographic Examination

1923 Radiographs are to be taken of the entire length of each welded seam, both longitudinal and circumferential. The surface of the weld is to be dressed smooth by chipping, grinding or other suitable means to the satisfaction of the Surveyor. The radiographs are to be marked in such a way that the corresponding portions of the welded seams can be readily and accurately identified. The radiographs are to be examined by the Surveyor who will indicate whether any repairs are necessary. On completion of repairs the affected portions of the seams are to be re-radiographed.

Penetrameters of approved type are to be placed at each end of each radiograph. They are to be placed adjacent to the welded seam and on the surface facing the source of radiation. The X-ray technique employed is to be such that the thickness of the penetrameter corresponding to 2 per cent of the thickness of the parent plate will be clearly shown on the radiograph.

The use of gamma rays may be permitted in exceptional circumstances, when details should be submitted for consideration.

Magnetic Crack Detection Examination

1924 Where vessels are made of carbon steel having a tensile strength exceeding 35 tons per square inch, or of alloy steel, all welds attaching standpipes, compensating plates, etc., to the vessel, which cannot be radiographed, are to be examined by magnetic crack detection, or other approved non-destructive methods.

Heat Treatment

1925 Each pressure vessel is to be efficiently heat treated on completion of the welding of all joints and attachments to shell and ends, and before the hydraulic test is carried out.

Heat treatment is to be carried out in a properly constructed and temperature controlled furnace and is to consist of heating the vessel slowly and uniformly to a suitable stress relieving temperature, soaking for a suitable period, followed by uniform cooling to atmospheric temperature. The temperature and soaking periods are to be selected which will relieve residual stress without undue reduction of material tensile strength.

Recommended temperatures for stress relief are given in the following table:—

Type of Steel	Soaking Temperature	
Carbon Carbon-manganese	580–620° C.	1080–1150° F.
$\frac{1}{2}$% Mo.	620–660° C.	1150–1220° F.
1% Cr. $\frac{1}{2}$% Mo.	620–660° C.	1150–1220° F.
$2\frac{1}{4}$% Cr. 1% Mo.	650–690° C.	1200–1270° F.

Soaking periods for the materials listed in the foregoing table are to be at least one hour per inch of plate thickness with a minimum period of one hour, except that for carbon and carbon manganese steels the period of soaking is to be increased by one hour, i.e. to one hour per inch of plate thickness plus one hour with a minimum period of two hours.

In cases where other materials are used for pressure vessel construction, full details of the proposed heat treatment are to be submitted for consideration.

1926 Where pressure vessels are of such dimensions that the whole length cannot be accommodated in the furnace at one time, the pressure vessels may be heated in sections provided sufficient overlap is allowed to ensure the heat treatment of the entire length of the longitudinal seam.

1927 Test plates should be heat treated in the same furnace and at the same time as the pressure vessels which they represent. In special cases, however, it may be permissible to heat treat the test plates separately from the pressure vessels provided the Surveyor is satisfied with the means adopted to ensure that the following factors will be the same for the pressure vessels as for their respective test plates:—

Rate of heating.
Maximum temperature.
Time held at maximum temperature.
Conditions of cooling.

1928 Where a number of test plates are heated together in a furnace, care is to be taken to ensure that each plate is uniformly exposed to the heat of the furnace.

1929 Where it is proposed to adopt special methods of heat treatment full particulars are to be submitted for consideration. In such cases it may be necessary to carry out tests to show the effect of the proposed heat treatment.

Hydraulic Test

1930 For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Where a vessel is designed for use at elevated temperatures a test pressure (TP) is to be applied, such that the vessel is subjected under hydraulic test to approximately the same wall stress as a vessel operating at a metal temperature below 650° F. as follows:—

$$TP = (1{\cdot}5WP + 50) \times \frac{\text{f at } 650^\circ \text{ F.}}{\text{f at working temperature}}$$

where f is the nominal stress obtained from Table 1.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

This hammer test is not required for vessels where the longitudinal and circumferential seams have been radiographed.

Modification of Requirements

1931 In the case of firms of large experience some modification may be permitted in regard to the requirements of 1904 to 1906.

Section 20

REQUIREMENTS FOR CLASS 2 FUSION WELDING

Preliminary Conditions

2001 Pressure vessels made in accordance with Class 2 requirements will be accepted only if constructed by firms whose works are properly equipped to undertake the welding of pressure vessels of this Class.

The welding plant is to be installed under cover and is to be maintained in an efficient working condition and adequate supervision of the welding work is to be provided.

It will be necessary for the Surveyors to visit the firm's works for the purpose of inspecting the welding plant, equipment and procedure and to arrange for the carrying out of preliminary tests similar to those described in 2010, 2011 and 2012.

On completion of the inspection and tests, the Surveyor's report including the results of the preliminary tests and particulars of the fusion welded pressure vessels previously constructed by the firm are to be submitted for the consideration of the Committee.

Routine Tests for Class 2 Fusion Welded Pressure Vessels

2002 Two test plates should be prepared for each pressure vessel. They should be attached to the shell plate in such a manner that the edges to be welded are a continuation and duplication of the corresponding edges of a longitudinal joint. The welding process, procedure and technique are to be the same as employed in the welding of the longitudinal joint. Test plates are to be so supported during welding that warping is reduced to a minimum.

2003 In cases where a number of Class 2 pressure vessels are made concurrently at the same works, and the plate thicknesses do not vary by more than $\frac{3}{16}$ inch, each 120 feet of welded seam, longitudinal plus circumferential, may be regarded as equivalent to one pressure vessel, the required number of test specimens being provided accordingly.

In these cases the thickness of the test plates is to be equal to that of the thickest shell plate used in the construction of the pressure vessels.

2004 The test plates are to be straightened before being subjected to the same heat treatment as given to the pressure vessel.

2005 Test plates need not be prepared for the circumferential seams, except in cases where a pressure vessel has circumferential seams only, or where the process for welding the circumferential joints is significantly different from that used for the longitudinal joints, when two test plates are to be prepared each having a welded joint which, so far as possible, is a duplication of the circumferential seams. Where a number of similar vessels are made at the same time, it will suffice if test plates are provided for each 100 feet of circumferential welded seam.

2006 The test plates are to be cut from the shell plate or plates forming the appropriate seam and before being detached are to be stamped by the Surveyor.

Where a number of similar welded pressure vessels are made concurrently at the same works, the test plates may be cut from one shell plate only provided the material is from the same cast.

When there is insufficient material available on the shell plates for the provision of test plates, acceptance may be given to test plates cut from another plate provided this plate is from the same cast and in the same heat treatment condition.

2007 The thickness of test plates is to be the same as that of the pressure vessel.

2008 One test plate is to be cut up into test specimens as shown in Fig. 11. All the specimens are to comply with the test requirements detailed in 2010 to 2012.

FIG. 11

		TENSILE
	WELD	BEND
	WELD	BEND
		NICKED BEND

Specimens may be dressed in way of the weld and the sharp edges may be removed from the bend specimens.

Retests

2009 If any of the tests fail, two retests are to be made on specimens cut from the second test plate. All retests are to comply fully with the test requirements.

Tensile Test

2010 The shape of the specimen is to conform to the requirements of J 1920.

The ultimate tensile strength of the joint is to be not less than the minimum specified for the plate.

In case of Class 2A vessels if the test piece breaks in the plate or fusion zone at not less than 95% of the minimum specified for the plate the test may be accepted.

Bend Tests

2011 The width of the bend specimens is to be not less than 1·5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. One specimen is to be bent with the outer surface of the weld in tension, and the other specimen is to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through an angle of 180 degrees over a former, the diameter of which is not greater than three times the thickness of the specimen.

Nicked Bend Tests

2012 The specimen is to have a slot cut into each side of the weld. The specimen is then to be broken in the weld and the fracture is to reveal a sound homogeneous weld, substantially free from slag inclusions, porosity and coarse crystallinity.

Heat Treatment

2013 Where heat treatment is required to be carried out in respect of any pressure vessel; the requirements of J 1810 and J 1925 to J 1929 are to be complied with.

Hydraulic Test

2014 Hydraulic test to be carried out in accordance with the requirements of J 1930.

Section 21

REQUIREMENTS FOR CLASS 3 FUSION WELDING

Preliminary Conditions

2101 Pressure vessels of Class 3 grade will be accepted without routine weld tests if constructed by firms whose works are equipped to undertake the welding of pressure vessels of this type. The Surveyors are to be satisfied that the welding equipment, procedure and supervision of the work are adequate, and are to test the quality of the welds by preliminary tests and occasional tests at their discretion.

Hydraulic Test

2102 For pressure vessels intended for working pressures up to 100 lb. per square inch, the hydraulic test pressure is to be twice the working pressure. Where working pressures exceed 100 lb. per square inch, the hydraulic test pressure is to be 1·5 times the working pressure plus 50 lb. per square inch.

Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 22

CONSTRUCTION AND INSPECTION OF FUSION WELDED PRESSURE VESSELS

Note :—The following requirements are applicable to all classes of fusion welded pressure vessels.

Electrodes

2201 Electrodes intended for use in the construction of pressure vessels are to be stored in a dry place. In order to ensure that the quality of the electrodes is being consistently maintained they are to be subjected to a regular system of periodic testing and inspection. Where routine tests are frequently carried out in respect of pressure vessels made in the normal course of production, such tests may be regarded as meeting the requirements of this paragraph.

Welding Technique

2202 Welding may be carried out by hand or by machine, and the current used in electric metallic arc welding may be direct or alternating. In welding branch pieces, pads and compensating rings, more than one run of weld metal is to be deposited. Longitudinal and circumferential seams may be reinforced by additional runs of weld metal.

Preheating

2203 Preheating is to be employed when necessitated by the joint restraint, thickness of the plate, and composition of the materials to be welded. Irrespective of plate thickness, welds in carbon steel, where the tensile strength is 35 tons per square inch or over, and welds in low alloy steels are to be preheated to a minimum temperature of 200° C. (392° F.). For carbon steels of lower tensile strength, preheating is to be used where the thickness exceeds $1\frac{3}{4}$ inches.

The method used for preheating is to be such as to ensure a uniformly heated band adjacent to the weld and to maintain the preheat temperature at all stages of welding until completion.

2204 The outer surfaces of the welds may be flush with the surfaces of the plates joined, but no objection will be raised if the total thickness at the centre of the weld is greater than the thickness of the plates, provided the change of section is gradual and there is no undercutting at the sides of the weld.

2205 Each run of weld metal is to be thoroughly cleaned and free from slag before the next run is deposited.

2206 Butt joints are to be welded from both sides of the plate where practicable. Before welding is commenced from the second side the weld metal at the bottom of the first side weld is to be removed by chipping or other approved method. Butt joints welded from one side, with or without backing strips, are acceptable only where access for an internal weld is not practicable. In the latter circumstances, it is to be demonstrated that there is complete penetration and fusion at the root of the weld.

2207 The welding of pressure vessels is to be carried out in the downhand horizontal position. In the case of circumferential seams means are to be adopted to ensure compliance with this requirement.

2208 In cases where it is proposed to adopt fusion welding processes in which it may not be possible to comply fully with the foregoing requirements regarding technique, full particulars are to be submitted for consideration.

Fabrication

2209 Before welding, the assembly is to be examined. The shape and size of the joints are to be in accordance with the approved design. The butting edges of the plates forming the longitudinal and circumferential seams are to be in line within a limit of 10 per cent of the plate thickness, but in no case exceeding $\frac{1}{8}$ inch for longitudinal joints and $\frac{3}{16}$ inch for circumferential joints.

2210 The attachment of branches should be examined before and after welding.

2211 During fabrication, the Surveyor is to be provided with opportunities for seeing the actual deposition of weld metal. The joints are to be examined at various stages during construction.

2212 On completion of the welding, the seams are to be thoroughly examined before being dressed or machined. Parts showing evidence of blow-holes, slag inclusions, unsatisfactory penetration, porosity, or any other defect, are to be cut out and rewelded, and excessive undercutting made good.

2213 Each pressure vessel is to be calibrated for distortion. The calibration is to be made after the heat treatment has been carried out. The drum or shell is to be circular at any section within a limit of one per cent of the

designed internal diameter based on the difference between the maximum and minimum diameters of any section. Any departure from circularity is to be gradual and there is to be no local flat in way of the welded seam.

Attachment of Fittings

2214 The attachment by welding of any fitting, brackets, lugs, etc., to the main pressure shell after the final stress relieving treatment, is not permitted, except where the material involved is mild steel. In such cases welding will only be permitted provided it is necessitated by the method of construction being employed and prior approval of the Surveyor must be obtained before any welding is carried out. In no circumstances is any welding to be done after heat treatment on vessels made of carbon or carbon-manganese steel with tensile strength exceeding 34 tons per square inch or of alloy steel.

When fittings, lugs, etc., are attached by welding to the main pressure shell, the material of these attachments is to be of weldable quality and the welding is to be of a comparable standard to that required for the vessel.

Section 23

FORGE WELDED PRESSURE VESSELS

General

2301 The term forge weld is, for the purpose of these Rules, applicable to joints made between plates which are welded together by means of hammering or rolling and in which no added metal is included.

Classification of Forge Welded Pressure Vessels

2302 **Class 1.** Pressure vessels made in accordance with the requirements of this class will be accepted only if they are constructed by firms whose names are included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels.

Approval of the following pressure vessels will only be given provided they be constructed and tested in accordance with the requirements of these Rules.

Pressure parts of boilers, and all fired pressure vessels intended for working pressure above 50 lb. per square inch.

In special circumstances relating to pressure, temperature and service conditions, it may be considered necessary to include other pressure vessels in the Class 1 category.

Class 2. This class includes all forge welded pressure vessels not included in Class 1.

Cylindrical Shells

2303 For pressure vessels operating at metal temperatures of 650° F. and under, the thickness of cylindrical shells is to be determined by the following formula, but no plate is to be less than $\frac{1}{4}$ inch thick.

$$WP = \frac{K \times S}{D}(T - \cdot 06), \qquad T = \frac{WP \times D}{K \times S} + \cdot 06$$

where WP = working pressure in lb. per square inch,

T = thickness of shell in inches,

S = minimum tensile strength in tons per square inch,

D = internal diameter of shell in inches,

K = 900 for Class 1 vessels,

= 790 for Class 2 vessels with shells $\frac{5}{8}$ inch thick and above,

= 730 for Class 2 vessels with shells less than $\frac{5}{8}$ inch thick.

2304 For Class 1 pressure vessels operating at metal temperatures exceeding 650° F. the thickness of cylindrical shells is to be determined by the appropriate formula of J 1602 in association with the permissible stresses at temperature of Table 1 for carbon and carbon-manganese steel.

Material

2305 The material used in the construction of pressure vessels is to be manufactured and tested in accordance with the relevant requirements of Chapter P.

The tensile strength of the material is to be between 24 and 30 tons per square inch with a range not exceeding 4 tons per square inch in any one case.

Preliminary Conditions and Tests for Class 1 Forge Welding

2306 In order that the name of a firm may be included in the list of firms recognised by the Committee for the manufacture of Class 1 forge welded pressure vessels, it will be necessary for the Surveyors to make a preliminary visit to the works for the purpose of inspecting the welding plant, equipment and procedure, also to arrange for the carrying out of a special series of tests as described in 2309. Subsequently the Surveyors will report periodically to the Committee on the conditions which obtain at the works, and if considered necessary will carry out further tests.

2307 The welding plant and equipment are to be of good quality and maintained in efficient working condition The welding plant is to be installed under cover and arranged so that the welding work may be carried out in positions free from draughts and adverse weather conditions. The

procedure is to be such that there is regular and systematic supervision of the welding work.

2308 The works should be equipped with an efficient testing laboratory which should include apparatus suitable for carrying out tensile, bend and impact tests, and micro-examination. The works should also be equipped with a suitable heat treating furnace having satisfactory means for temperature control, but as an alternative, arrangements may be made whereby pressure vessels can be heat treated elsewhere.

2309 A series of special preliminary tests to demonstrate the quality of the welding work is to be carried out. The tests should include tensile, bend, impact, hardness and fatigue tests on specimens which should be prepared in a similar manner to that used in the making of longitudinal joints in pressure vessels. The Surveyors are to select portions of the test plates from which photomicrographs, at 100 and 300 magnifications, are to be prepared representing the weld centre and the plate remote from the weld.

2310 A full size pressure vessel is to be manufactured under survey, and is to comply in every respect with the requirements for Class 1 forge welded pressure vessels.

2311 In the case of firms of large experience some modification may be permitted in regard to the requirements of 2309, provided satisfactory evidence is produced of successful results obtained by the firm's welding methods, over an appreciable period.

Routine Tests for Forge Welded Pressure Vessels

Class 1

2312 The shell plates of each pressure vessel are to be left long enough to accommodate the following test specimens:—

Two tensile specimens, } with provision
Four bend specimens, } for retests.

Retests

2313 If any of the tests fail, two retests are to be made, both of which are to comply fully with the test requirements.

Tensile Test

2314 The tensile specimens are to conform to the standard test piece A (*see* P 312), and the mid portion of the specimens is to coincide with the centre line of the weld.

The ultimate tensile strength of both test pieces is to be not less than 95 per cent of the minimum specified for the plate material. The elongation is to be not less than 18 per cent on a gauge length of 8 inches.

Bend Tests

2315 The width of the bend specimens is to be not less than 1·5 times the thickness, and the mid portion of the specimens is to coincide with the centre line of the weld. Two specimens are to be bent in such a manner that the outer surface of the weld is in tension, and two specimens are to be bent with the outer surface of the weld in compression.

In both cases the specimens are to be bent without fracture through 180 degrees round a former, the diameter of which is not greater than three times the thickness of the specimen.

NOTE:—Some modification of the requirements contained in 2312 may be permitted in circumstances such as are indicated in 2311.

Test pieces for Circumferential Seams

2316 In the case of pressure vessels having circumferential joints only, no test pieces need be provided unless the internal diameter of the pressure vessel exceeds 4 feet 6 inches, when a representative welded joint is to be made and cut up to provide the specimens detailed above.

Class 2

2317 In the case of forge welded pressure vessels other than those included in Class 1, routine tests are not required in respect of longitudinal joints, but where the internal diameter of a pressure vessel exceeds 4 feet 6 inches the manufacturer is to produce authoritative evidence of test results demonstrating that efficient circumferential welds of the proposed dimensions can be made consistently.

Weld Thickness

2318 On completion of the welding the thickness at and adjacent to the weld is to be not less than the required thickness of the shell plate as determined from the formulæ for working pressure given in J 1602, J 1603 and J 1815.

Heating

2319 The heating of plates for welding is to be carried out by means of a process which will provide a flame which will not be of an oxidizing character and will not tend to introduce impurities into the steel. Provision is to be made for careful control of the welding heat.

Heat Treatment

2320 All forge welded pressure vessels are to be efficiently normalised by heating uniformly to a temperature of 920° C. (1690° F.) and allowed to cool in still air.

The heat treatment is to be carried out in accordance with the requirements of J 1925 to J 1929, so far as these are applicable.

Hydraulic Test

2321 Pressure vessels are to be subjected to a hydraulic test pressure of twice the working pressure. Whilst under this test the pressure vessel is to be well hammered on both sides of, and close to, the welded seams.

Section 24

AIR RECEIVERS

2401 Cylindrical receivers for containing air under high pressure may be made either of seamless steel or of welded, or riveted, steel plates.

Welded Receivers

2402 Receivers of fusion or forge welded construction are to comply with the requirements of J 18 to J 23.

Riveted Receivers

2403 Receivers of riveted construction are to comply with the Rules for cylindrical boilers, where applicable.

Dished End Plates

2404 Where end plates are dished to partially spherical form and not fitted with stays, the scantlings may be determined by the following formula:—

$$WP = \frac{C \times S \times T}{R}$$

where WP = working pressure, in lb. per square inch,

C = 576 for ends concave to pressure,

= 370 for ends convex to pressure,

S = minimum tensile strength of the plates, in tons per square inch,

T = thickness of the end, in inches, after dishing,

R = inside radius of curvature of the end, in inches, which is not to exceed the diameter of the shell.

Ends convex to pressure are not to be used for receivers exceeding 24 inches internal diameter.

If desired the formula J 1605 may be used in determining the scantlings of dished ends subject to pressure on the concave side.

The inside corner radius is to be not less than four times the thickness of the end plate and in no case less than $2\frac{1}{2}$ inches.

Where the end is provided with a flanged manhole the thickness of the end, in inches, determined by the foregoing formula is to be increased by $\frac{1}{8}$ inch and the depth (F) of the manhole flange, measured in inches from the outer surface at the minor axis is to be not less than

$$F = \sqrt{T_1 \times W}$$

where T_1 = required thickness of the end plate, in inches,

W = minor axis of the manhole, in inches.

Seamless Receivers

2405 The material used is to comply with the requirements of P 322.

2406 The permissible working pressure for seamless receivers is to be determined by the following formulæ:—

$$WP = \frac{C \times S \times (t - 4)}{D}$$

for thicknesses of $\frac{5}{8}$ inch and above.

$$WP = \frac{C \times S \times (t - 2)}{D}$$

for thicknesses below $\frac{5}{8}$ inch.

where WP = working pressure, in lb. per square inch,

S = minimum tensile strength of the steel shell plates, in tons per square inch,

t = thickness of the shell plates, in 32nds of an inch,

D = internal diameter, in inches,

C = 38·5 for receivers of thickness $\frac{5}{8}$ inch and above,

34·5 for receivers of thickness below $\frac{5}{8}$ inch.

2407 Each seamless receiver is to be carefully annealed after manufacture, and before the hydraulic test.

Hydraulic Test

2408 Each seamless receiver is to be subjected to a hydraulic test of twice the working pressure, which it is to withstand without permanent set.

2409 Each receiver made of riveted steel plates for pressures up to 300 lb. per square inch is to be tested by hydraulic pressure to 1·5 times the working pressure, plus 50 lb. per square inch. Where higher working pressures are used, the test pressure need not be more than 200 lb. per square inch above the working pressure.

General

2410 All receivers above 6 inches internal diameter are to be so made that the internal surfaces may be examined and, wherever practicable, the openings for this purpose are to be sufficiently large for access. Means are to be provided for cleaning the inner surfaces by steam, or otherwise.

2411 Each receiver which can be isolated from a safety valve is to be provided with a suitable fusible plug to discharge the contents in case of fire.

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2412 Each receiver is to be fitted with a drain arrangement at its lowest part, permitting oil and water to be blown out.

Cross Reference

2413 For scantlings of compressed air pipes, *see* E 506 and E 512.

Periodical Surveys

2414 For periodical survey requirements, *see* Chapter C.

APPENDIX

Firms recognised by the Committee for the Manufacture of Class 1 Welded Pressure Vessels.

Note: The Society's Office giving attendance at the Works is shown in brackets.

FUSION WELDING

United Kingdom

Adamson, Daniel, & Co., Ld., Dukinfield, Cheshire. (Manchester.)

Adamson, Joseph, & Co., Ld., Hyde, Cheshire. (Manchester.)

Aiton & Co., Ld., Derby. (Nottingham.)

Ashmore, Benson, Pease & Co., Ld., Parkfield Works, Stockton-on-Tees. (Middlesbrough.)

Autodrome (Engineers) Ld., Shipley Works Estate, Shipley Road, Audenshaw, Nr. Manchester. (Manchester.)

Babcock & Wilcox, Ld., Renfrew. (Glasgow.)

Balfour, Henry, & Co., Ld., Leven, Fife. (Leith.)

Brown, John, & Co., Ld., Clydebank. (Glasgow.)

Brown, John, Land Boilers, Ld., Whitecrook Works, Clydebank. (Glasgow.)

Butterfield, W. P. (Engineers) Ld., P.O. Box No. 38, Shipley, Yorks. (Leeds.)

Central Marine Engine Works (Wm. Gray & Co., Ld.). (West Hartlepool.)

Clark, Geo. & North Eastern Marine (Sunderland) Ld., Southwick Eng. Works. (Sunderland.)

Clarke, Chapman & Co., Ld., Gateshead. (Newcastle.)

Clayton, Son & Co., Ld., Pepper Road Works and Moor End Works, Hunslet, Leeds 10. (Leeds.)

Cochran & Co. (Annan) Ld., Annan. (Glasgow.)

Danks, Edwin, & Co. (Oldbury) Ld. (Birmingham.)

Danks of Netherton Ld., Netherton. (Birmingham.)

Davey, Paxman & Co., Ld., Standard Ironworks, Colchester, Essex. (London.)

English Electric Co., Ld., Netherton Works, Netherton, Lancs. (Liverpool.)

English Electric Co., Ld., Stafford. (Birmingham.)

Farrar Boilerworks Ld., Newark-on-Trent. (Nottingham.)

Firth, Thomas, & John Brown Ld., Atlas Works, Sheffield. (Sheffield.)

Foster, Yates & Thom, Ld., Canal Works, Blackburn. (Manchester.)

Fraser, W. J., & Co., Ld., Monk Bretton, near Barnsley. (Sheffield.)

Grazebrook, M. & W., Ld., Dudley, Worcestershire. (Birmingham.)

Harland & Wolff, Ld., Belfast. (Belfast.)

Harvey, G. A., & Co. (London), Ld., London, S.E.1. (London.)

Head, Wrightson & Co., Ld., Thornaby-on-Tees. (Middlesbrough.)

Horseley Bridge & Thomas Piggott, Ld., Tipton, Staffs. (Birmingham.)

International Combustion Ld., Derby. (Nottingham.)

Jenkins, Robert, & Co., Ld., Rotherham. (Sheffield.)

Markham & Co., Ld., Broad Oak Works, Chesterfield. (Sheffield.)

Marshall & Anderson, Ld., Manse Road, Motherwell. Works:—Broomside. (Glasgow.)

Marshall, Sons & Co., Ld., Britannia Works, Gainsborough, Lincs. (Sheffield.)

Millspaugh, Ld., Sheffield. (Sheffield.)

Motherwell Bridge & Engineering Co., Ld., Motherwell. (Glasgow.)

Newton Chambers & Co., Ld., Thorncliffe. (Sheffield.)

Robey & Co., Ld., Globe Works, Lincoln. (Nottingham.)

Ruston & Hornsby, Ld., Lincoln. (Nottingham.)

South Durham Steel & Iron Co., Ld., Stockton-on-Tees. (Middlesbrough.)

Stephen, Alexander, & Sons, Ld., Glasgow. (Glasgow.)

Thompson, John (Wolverhampton) Ld., Wolverhampton. (Birmingham.)

Towler & Son, Ld., London, E.15. (London.)

Vickers-Armstrongs (Engineers) Ld., Elswick Works, Newcastle-on-Tyne. (Newcastle.)

Watson, Robert, & Co. (Constructional Engineers) Ld., Bolton, Lancs. (Manchester.)

Weir, G. & J., Ld., Cathcart, Glasgow. (Glasgow.)

Whessoe, Ld., Darlington. (Middlesbrough.)

Wright's Forge & Engineering Co., Ld., Tipton, Staffs. (Birmingham.)

Yarrow & Co., Ld., Scotstoun, Glasgow. (Glasgow.)

Australia

Babcock & Wilcox of Australia Pty., Ld., Regents Park, N.S.W. (SYDNEY.)
Cockatoo Docks & Engineering Co., Pty., Ld., Sydney, N.S.W. (SYDNEY.)
Commonwealth Ordnance Factory, Maribyrnong, Victoria. (MELBOURNE.)
Perry Engineering Co., Ld., Adelaide, S. Australia. (ADELAIDE.)
Smith, Bernard, Pty., Ld., Sydney, N.S.W. (SYDNEY.)
Thompsons (Castlemaine) Ld., Melbourne, Victoria. (MELBOURNE.)
Tomlinson Steel Ld., Perth, Western Australia. (FREMANTLE.)

Austria

Vereinigte Osterreichische Eisen-und-Stahlwerke A.G., Linz an der Donau. (VIENNA.)
Waagner-Biro Aktiengesellschaft, Graz, Styria. (VIENNA.)

Belgium

Chaudronneries Pierre Brouhon, S.A., Awans-Bierset-lez-Liege. (ANTWERP.)
Cockerill-Ougrée, S.A., Seraing. (ANTWERP.)

Brazil

Babcock & Wilcox (Caldeiras) S.A., Resende, Brazil. (RIO DE JANEIRO.)

Canada

Canadian General Electric Co., Ld. (Canadian Allis-Chalmers, Ld.), Davenport Works, Toronto. (TORONTO.)
Canadian Vickers, Ld., Montreal. (MONTREAL.)
Davie Shipbuilding, Ld., Lauzon, P.Q. (MONTREAL.)
Dominion Bridge Co., Ld., Lachine, Quebec. (MONTREAL.)
Foster Wheeler, Ld., St. Catharines, Ontario. (TORONTO.)
Inglis, John, & Co., Ld., Toronto. (TORONTO.)
Vancouver Iron Works, Ld., Vancouver, B.C. (VANCOUVER.)

Denmark

Aalborg Vaerft A/S., Aalborg. (AALBORG.)
Burmeister & Wain, A/S., Copenhagen. (COPENHAGEN.)
Helsingor Skibsvaerft & Maskinbyggeri, Elsinore. (COPENHAGEN.)

Finland

Valmet Oy, Rautpohjan tehdas, Jyvaskyla. (ABO.)
Wartsila-koncernen A/B, Maskin och Bro, Helsingfors. (HELSINGFORS.)

France

Ateliers & Chantiers de la Seina Maritime, Le Trait. (ROUEN.)
Brissonneau & Lotz, Nantes. (NANTES.)
Chantiers de l'Atlantique (Penhoët-Loire), St. Nazaire. (NANTES.)
Compagnie de Fives-Lille, Fives-Lille, Nord. (VALENCIENNES.)
Sté. des Chantiers Reunis Loire-Normandie, (Chantier de Nantes). (NANTES.)
Sté. Francaise des Constructions Babcock & Wilcox, La Courneuve, Seine. (ROUEN.)

Germany

Borsig A.G., Berlin-Tegel. (BERLIN.)
Bremer Vulkan, Bremen-Vegesack. (BREMEN.)
Deutsche Babcock & Wilcox Dampfkesselwerke A.G., Oberhausen. (DUSSELDORF.)
Deutsche Werft A.G., Hamburg. (HAMBURG.)
Guttehoffnungshütte Oberhausen A.G., Werke Sterkrade, Oberhausen-Sterkrade. (DUSSELDORF.)
Howaldtswerke A.G., Kiel. (KIEL.)
Klockner-Georgsmarienwerke A.G., Osnabruck. (HANOVER.)
Koerver & Lersch, Krefeld. (DUSSELDORF.)
Krupp Maschinenfabriken, Fried., Essen. (DUSSELDORF.)
Mannesmann Hüttenwerke A.G., Duisburg-Huckingen. (DUSSELDORF.)
Maschinenfabrik Augsburg-Nürnberg A.G., Augsburg. (AUGSBURG.)
Maschinenfabrik Augsburg-Nürnberg A.G., Gustavsburg. (MANNHEIM.)
Maschinenfabrik Augsburg-Nurnberg A.G., Werk Hamburg, Hachmannkai, Hamburg, 11, (HAMBURG.)
Phoenix-Rheinrohr A.G., Mulheim, Ruhr. (DUSSELDORF.)
Pintsch-Bamag A.G., Alteburgerstr. 300, Koln-Bayenthal, (KOLN).
Ruhrstahl A.G., Henrichshütte, Hattingen-Ruhr. (DORTMUND.)
Siller & Jamart, Wuppertal-Barmen. (DUSSELDORF.)
Stahl-und-Röhrenwerke Reisholz A.G., Dusseldorf-Reisholz. (DUSSELDORF.)
Steinmuller, L. & C., G.m.b.H., Gummersbach/Rhld. (HAMBURG.)
Weser A.G., Bremen. (BREMEN.)

Holland

"Breda," N.V. Machinefabrik, v/h Backer & Rueb, Rotterdam. (ROTTERDAM.)
Bronswerk-Amaf., Amersfoort. (AMSTERDAM.)
Jonker, N.V. Hk., & Zoon, Amsterdam. (AMSTERDAM.)

Holland—*continued*

Kon. Mij. "De Schelde" N.V., Vlissingen. (ROTTERDAM.)
Nederlandsche Dok en Scheepsbouw Mij. (AMSTERDAM.)
Nederlandsche Electrolasch Mij. N.V., Leiden. (ROTTERDAM.)
Rotterdamsche Droogdok Maatschappij, N.V., Rotterdam. (ROTTERDAM.)
Stork, Gebr., & Co. N.V., Hengelo. (AMSTERDAM.)
Werkspoor, N.V., Amsterdam. (AMSTERDAM.)

Italy

Acciaieria & Tubificio di Brescia, Brescia. (GENOA.)
Ansaldo Stabilimento Meccanico, Genoa. (GENOA.)
Cantieri Riuniti dell'Adriatico. (TRIESTE.)
C.I.P.I. Costruzioni Impianti Petroliferi Industriali, Marghera, Venice (Also known as "Guido Sartori," Venice.) (VENICE.)
Franco Tosi S.p.A., Legnano. (GENOA.)
Nuovo Pignone, Industrie Meccaniche e Fonderia S.p.A., Stabilimento di Massa, Apuania. (GENOA.)
Terni, Società per l'Industria e l'Elettricità, Terni. (NAPLES.)

Japan

Babcock-Hitachi Kabushiki Kaisha, Yokohama. (YOKOHAMA.)
Fuji Denki Seizo K.K., Kawasaki Works, Kawasaki. (YOKOHAMA.)
Harima Shipbuilding & Engineering Co., Ld., Aioi. (KOBE.)
Hitachi, Ld., Hitachi Works, Ibaragi-Ken. (YOKOHAMA.)
Hitachi Ld., Kure Works, Kure-Shi, Hiroshima-Ken. (SHIMONOSEKI.)
Hitachi Shipbuilding & Engineering Co., Ld., Innoshima Shipyard, Innoshima. (KOBE.)
Hitachi Shipbuilding & Engineering Co., Ld., Sakurajima Shipyard, Osaka. (KOBE.)
Ishikawajima Heavy Industries, Tokyo. (YOKOHAMA.)
Ishikawajima Shibaura Turbine Co., Ld., Tsurumi Works, Yokohama. (YOKOHAMA.)
Kawasaki Dockyard Co., Ld., Kobe. (KOBE.)
Kobe Shipyard & Engine Works, Mitsubishi Heavy Ind., Reorganised, Ld., Kobe. (KOBE.)
Maizuru Dockyard, Iino Sangyo Kaisha, Ld., Amarube, Maizuru. (KOBE.)
Mitsubishi Shipbuilding & Engineering Co., Ld., Hiroshima. (KOBE.)
Mitsui Shipbuilding & Engineering Co., Ld., Tamano. (KOBE.)
Nagasaki Works, Mitsubishi Zosen Kabushiki Kaisha, Nagasaki. (KOBE.)
Nippon Steel Tube Co., Tsurumi. (YOKOHAMA.)
Uraga Shipbuilding Yard, Uraga Dock Co., Ld., Yokosuka. (YOKOHAMA.)
Yokohama Shipyard & Eng. Works, Mitsubishi Nippon Heavy Industries, Ld. (YOKOHAMA.)
Yokoyama Engineering Co., Ld., Kawasaki Works, Kawasaki. (YOKOHAMA.)

Norway

Elektrisk Sveisning A/S, Töyenbekken, 34, Oslo. (OSLO.)

Poland

Huta Ferrum, Katowice. (GDANSK.)
Stocznia Gdansk (Gdansk Shipbuilding, Marine Engineering & Boiler Works), Gdansk. (GDANSK.)

South Africa

Babcock & Wilcox of Africa (Pty.), Ld., Houtkop Rd., Duncanville-Vereeniging. (VEREENIGING.)
Thompson, John. Africa (Pty.) Ld., Bellville, Cape Province. (CAPE TOWN.)
Vanderbijl Engineering Corporation, Ld., Vecor Works, Vanderbijl Park, N.W.7, Transvaal. (VEREENIGING.)

Spain

Empresa Nacional Bazan, El Ferrol. (BILBAO.)
La Maquinista Terrestre Maritima, S.A., Barcelona. (BARCELONA.)

Sweden

Aktiebolaget Gotaverken, Gothenburg. (GOTHENBURG.)
Avesta Jernverks A/B, Avesta. (STOCKHOLM.)
Degerfors Jernverks A/B, Degerfors. (GOTHENBURG.)
Eriksbergs Mek. Verkstads A/B, Gothenburg. (GOTHENBURG.)
Landsverk A/B, Landskrona. (HELSINGBORG.)
Lindholmens Varv. A/B, Gothenburg. (GOTHENBURG.)
Marinverkstäderna, Örlogsvarvet, Karlskrona. (MALMO.)
Motala Verkstad A/B, Motala. (GOTHENBURG.)
Pullmax A/B, Gothenburg. (GOTHENBURG.)
Svenska Maskinverken, A/B, Kallhall Works. (STOCKHOLM.)

Switzerland

Brown-Boveri, Ld., Baden. (WINTERTHUR.)
Sulzer Bros. Ld., Winterthur. (WINTERTHUR.)

U.S.A.

Babcock & Wilcox Co., Barberton, Ohio. (CLEVELAND, OHIO.)
Bethlehem Steel Co., Bethlehem, Pa. (PHILADELPHIA.)
Bethlehem Steel Co., Shipbuilding Division, Quincy Works, Mass. (BOSTON.)

U.S.A.—*continued*

Chicago Bridge & Iron Co., Birmingham, Alabama. (MOBILE.)

Combustion Engineering Co., Inc., New York.
Works at Chattanooga, Tennessee. (MOBILE.)
Works at St. Louis. (PHILADELPHIA.)

Downington Iron Works, Inc., Downington, Pa. (PHILADELPHIA.)

Erie City Iron Works, Erie, Pa. (CLEVELAND, OHIO.)

Farrar & Trefts, Inc., Buffalo, N.Y. (CLEVELAND, OHIO.)

Foster Wheeler Corporation, Carteret, N.J. (NEW YORK.)

Foster Wheeler Corporation, Mountaintop, Pa. (PHILADELPHIA.)

Griscom-Russel Co., Massillon, Ohio. (CLEVELAND, OHIO.)

Johnston Brothers, Inc., Ferrysburg, Michigan. (CLEVELAND, OHIO.)

Kellogg, M. W., Co., Jersey City 3, N.J. (NEW YORK.)

Smith, A. O., Corporation, Milwaukee, Wisconsin. (NEW YORK.)

Sun Shipbuilding & Dry Dock Co., Chester, Pa. (PHILADELPHIA.)

FORGE WELDING

Thompson, John (Wolverhampton) Ld., Wolverhampton. (BIRMINGHAM.)

August, 1961

Chapter K

SPARE GEAR FOR STEAM AND INTERNAL COMBUSTION MACHINERY INSTALLATIONS

FOR THE EFFICIENT OPERATION OF THE SHIP THE FOLLOWING ARTICLES OF SPARE GEAR, SO FAR AS THEY ARE APPLICABLE, SHOULD BE SUPPLIED. OWNERS SHOULD ARRANGE TO REPLACE OR MAKE GOOD USED ITEMS AS OPPORTUNITY OCCURS.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	MAIN PROPELLING MACHINERY			
	STEAM RECIPROCATING ENGINES (*See also* items 20 and 21)			
1	Connecting Rod Bearings	1	1	Bottom end bearing complete with liners, bolts and nuts.
		1	1	Top end bearing complete with liners, bolts and nuts for one connecting rod.
2	Piston Rings	1 set	1 set	Rings and springs for H.P. Piston.
3	Piston Valve Rings	1 set	—	Rings and springs, of each size used.
4	Piston Rod Metallic Packing	1	—	Complete set of packing for H.P. piston rod and valve spindle.
5	Poppet Valves	1	—	Valve complete with cage, spindle and bush, of each size used, together with rollers and springs.
	STEAM TURBINES (*See also* items 20 and 21)			
6	Bearing Bushes	1	—	Complete bearing bush, of each size and type used, for the rotor, pinion and gear wheel shafts, for one engine.
7	Turbine Thrust	1 set	1 set	Pads of each size for one face of Michell type thrust, or rings for turbine adjusting block, of each size used for one engine. Assorted liners for 1 block where fitted.
	HEAVY OIL ENGINES (*See also* items 20 and 21)			
8	Valves	2	2	Exhaust valves complete with valve casings, springs and other fittings.
		1	1	Air inlet valve complete with valve casing, springs and other fittings.
		1	1	Starting air valve on cylinder complete with valve casing, springs and other fittings.
		½ set	¼ set	Fuel valves, of each size and type used, complete with all fittings, for one engine.
		1	1	Cylinder relief valve complete.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
9	Piston (including piston exhaust valves where used)	1	—	*Crosshead Type.* Piston, of each size used, complete with rings, studs and nuts.
		1	—	*Trunk Piston Type.* Piston of each size used, complete with skirt, rings, studs, nuts and gudgeon pin.
10	Piston Rings (including rings for piston exhaust valves where used)	1 set	1 set	Rings, of each size used, for one cylinder.
11	Piston Cooling Pipes	2 sets	1 set	Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit.
12	Connecting Rod Bearings	1	1	Bottom end bearing of each type fitted complete with liners, bolts and nuts.
		1	—	Top end bearing of each type fitted complete with liners, bolts and nuts.
		1	1	Gudgeon pin bush, where trunk pistons are used.
13	Scavenge Blower NOTE : Where there are two scavenge blowers connected to all cylinders, spare gear may be omitted provided the engines can manœuvre satisfactorily when one of the blowers is not in action.	1 set	—	Rotors, rotor shafts, bearings and synchronising gear wheels or equivalent working parts if of other types.
14	Valves for Scavenge System	¼ set	¼ set	Suction and delivery valves, for one engine.
15	Gear and Chain Drives for Camshafts, Scavenge Blowers, Compressors, Fuel Pumps, Cooling Water Pumps, Bilge Pumps and Lubricating Oil Pumps (excluding cylinder lubricators).	1 set	—	*Gear Wheel Drive.* Wheels for the drive of one engine.
		6	—	*Chain Drive.* Separate links with pins and rollers of each size used.
16	Fuel Pumps	1	1	Pump complete.
17	Reduction and/or Reverse Gear Case Bearing Bushes	1	—	Complete bearing bush, of each size fitted in the gear case assembly.
		1	—	Roller or ball race, of each size fitted in the gear case assembly.
18	Main Engine Driven Air Compressor	1 set	1 set	Piston rings of each size used.
		½ set	½ set	Suction and delivery valves complete, of each size used.
19	Fuel Pipes	1	1	Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	APPLICABLE TO ALL TYPES OF MAIN ENGINES			
20	Main Thrust Blocks	1 set	1 set	Pads for one face of Michell type thrust block
				or
		1	1	Complete white metal thrust shoe of solid ring type
				or
		1	1	Inner and outer race with rollers where roller thrust bearings are used.
21	Coupling Bolts	1 set	—	Bolts, of each size used, for one coupling.
	ELECTRIC PROPELLING MACHINERY	For items of spare gear to be carried *see* M 20.		

AUXILIARY MACHINERY

Where additional units of adequate capacity are fitted no spare gear is required.

AUXILIARY HEAVY OIL ENGINES **For each size of** engine required **for essential services.**

22	Valves	2	2	Exhaust valves complete with valve casings, springs and other fittings.
		1	1	Air inlet valve, complete with valve casing, springs and other fittings.
		1	1	Starting air valve on cylinder complete with valve casing, springs and other fittings.
		½ set	¼ set	Fuel valves of each size used, complete with all fittings, for one engine.
		1	1	Cylinder relief valve complete.
23	Piston Rings	1 set	1 set	Rings of each size used, for one cylinder.
24	Piston Cooling Pipes	2 sets	1 set	Telescopic cooling pipes and fittings or their equivalent, for a cylinder unit.
25	Connecting Rod Bearings	1	1	Bottom end bearing of each type fitted complete with liners, bolts and nuts.
		1	1	Gudgeon pin bush, where trunk pistons are used.
26	Valves for Scavenge System	¼ set	¼ set	Suction and delivery valves, for one engine.
27	Fuel Pumps	1	1	Pump complete.
28	Fuel Pipes	1	1	Length of pipe of the greatest length used, complete with flanges or unions, for the fuel delivery to the cylinders.

ITEM NO.	ITEM	SPARE PARTS REQUIRED TO BE SUPPLIED		
		NUMBER REQUIRED FOR		SPARE PART
		OCEAN GOING SHIPS	SHORT VOYAGE SHIPS	
	AUXILIARY STEAM ENGINES	For each size of engine required for essential services.		
29	Connecting Rod Bearings	1	1	Bottom end bearing complete with liners, bolts and nuts.
		1	1	Top end bearing complete with liners, bolts and nuts.
30	Piston Rings	1 set	1 set	Rings.
	TURBINES DRIVING ESSENTIAL AUXILIARIES	Spare gear to be the same as for main steam turbines in so far as applicable.		
	AUXILIARY AIR COMPRESSOR			
31	Piston Rings	1 set	1 set	Rings, of each size used, for one piston.
32	Valves	½ set	½ set	Suction and delivery valves, complete, of each size used.
	ELECTRICAL EQUIPMENT	For items of spare gear to be carried *see* M 20.		
	REFRIGERATING INSTALLATIONS IN SHIPS	For items of spare gear to be carried *see* N 6.		
	BOILERS			
	MAIN AND AUXILIARY BOILERS			
33	Tube Stoppers or Plugs	20	10	Tube stoppers or plugs, of each size used, for boiler, superheater and economiser tubes.
34	Fire Bars	1 set	½ set	Fire bars for one boiler, where coal fired.
35	Oil Fuel Burners	1 set	1 set	Oil fuel burners complete, for one boiler.
36	Gauge Glasses	2 sets per boiler	2 sets per boiler	Gauge glasses of round type.
		1 set for every two boilers	1 set for every two boilers	Gauge glasses of flat type.
	DONKEY BOILERS			
37	Tube Stoppers or Plugs	6	6	Tube stoppers or plugs, complete.
38	Oil Fuel Burners	1 set	1 set	Oil fuel burners, complete, for one boiler.

13th December, 1951

Chapter M

ELECTRICAL EQUIPMENT AND ELECTRIC PROPELLING MACHINERY

Section 1

GENERAL REQUIREMENTS

101 (*a*) The requirements of this Chapter apply to passenger ships and cargo ships except where otherwise stated. While these requirements are considered to meet those of the 1948 Safety of Life at Sea Convention, attention should be given to any relevant statutory regulations of the National Authority of the country in which the ship is to be registered.

(*b*) In passenger ships services essential for safety are to be maintained under emergency conditions and the safety of ship and personnel from electrical hazards are to be assured.

(*c*) This Chapter states requirements for those features of the electrical installation which are considered essential for the safety of the ship. The design and installation of other equipment is to be such that there is no risk of fire due to its failure. It must, as a minimum, comply with a national or international standard.

(*d*) The Committee will be prepared to give consideration to special cases or to arrangements which are equivalent to the Rules. Consideration will also be given to the electrical arrangements of small ships to be assigned class notations for restricted or special services.

(*e*) Electrical installations for propulsion and auxiliary services are to be constructed and installed in accordance with the relevant sections of this Chapter and are to be inspected and tested by the Surveyors.

Plans

102 The following plans and particulars are to be submitted in triplicate, for consideration :—

Propulsion Equipment

Plans of generators, motors and seatings together with diagrams of control gear, cables and circuits, and particulars of voltage, current, power and speed with a key diagram and explanation of the system in relation to the requirements of M 17.

Electric Slip Couplings

Plans showing the scantlings and construction of the couplings together with diagrams of electrical components, switchgear and control gear.

Electrical Equipment (other than propulsion equipment)

The arrangement plan and circuit diagram of the switchboard(s). Diagrams of the wiring system including cable sizes, type of insulation, normal working current in the circuits and the capacity, type and make of protective devices. Calculations of short circuit currents at main busbars, sub-switchboard busbars and the secondary side of transformers are to be submitted. (*See* M 610.)

Welding on Shafts

Where welding is to be applied to shafts of machines for essential services for securing armature arms or spiders, plans showing the construction are to be submitted for consideration.

Prime Movers

See G 104.

Tankers (compartments in between deck spaces)

See M 1605.

Additions or Alterations

103 An addition, temporary or permanent, is not to be made to the approved load of an existing installation until it has been ascertained that the current-carrying capacity and the condition of the existing accessories, conductors and switchgear are adequate for the increased load. (*See* C 107.)

Plans are to be submitted for approval and the alterations or additions are to be carried out under the inspection and to the satisfaction of the Surveyors.

Application

104 Except where a specific statement is made to the contrary all requirements of this Chapter are applicable to both alternating current and direct current installations.

105 D.C. equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent.

A.C. equipment is to operate satisfactorily under voltage fluctuations of plus 6 per cent and minus 10 per cent at rated frequency and under frequency fluctuations of plus or minus 3 per cent at rated voltage.

Contactors and similar equipment are not to drop out at 85 per cent rated voltage.

Ambient Temperatures

106 The following cooling air and cooling water temperatures are applicable in ships classed for :—

(*a*) Unrestricted Service

(i) Primary cooling water supply 30° C. (86° F.)

(ii) Cooling air temperature 45° C. (113° F.)

(*b*) Restricted Service (*See* B 107 and B 108)

Vessels intended solely for use in Northern or Southern waters outside the tropical belt.

(i) Primary cooling water supply 25° C. (77° F.)

(ii) Cooling air temperature 40° C. (104° F.)

Location and Construction

107 Electrical equipment is to be accessibly placed clear of inflammable material in well ventilated, adequately lighted spaces in which inflammable gases cannot accumulate and where it is not exposed to risk of mechanical injury or damage from water, steam or oil. Where necessarily exposed to such risks the equipment is to be suitably constructed or enclosed. Live parts are to be guarded where necessary.

Insulating materials and insulated windings are to be resistant to tracking, moisture, sea air and oil vapour unless special precautions are taken to protect them.

Equipment is not to remain alive through the control circuits and/or pilot lamps when switched off by the control switch. This does not apply to synchronizing switches and/or plugs.

The operation of all electrical equipment and the lubricating arrangements are to be efficient under such conditions of vibration and shock as arise in normal practice, and with the ship inclined from the normal at any angle up to 15 degrees transversely, when pitching 10 degrees longitudinally and when rolling up to 22·5 degrees from the vertical.

All nuts and screws used in connection with current carrying parts and working parts are to be effectively locked.

Conductors and equipment are to be placed at such a distance from the magnetic compasses or are to be so disposed that the interfering magnetic field is negligible even when circuits are switched on and off.

Where electric power is used for propulsion, the equipment is to be arranged so that it will operate satisfactorily in the event of partial flooding by bilge water above the tank top up to floor plate level. (*See* E 223 and E 224.)

Earthing

108 Non-current-carrying metal parts of electrical equipment are to be effectively earthed. Where earthing connections are necessary they are to be of copper or other approved material and are to be protected against damage and, where necessary, electrolytic action. They are to be equal to at least half the cross section of the cable supplying the equipment with a minimum of 0·003 sq. in. (2 sq. mm.).

Flameproof and Intrinsically Safe Equipment

109 Where risk of explosion might otherwise arise, equipment is to be of flameproof or intrinsically safe type.

Where equipment is required to be of flameproof or intrinsically safe type and equipment of suitable type is obtainable which has been type tested and approved by a competent independent Testing Authority, it will be sufficient to furnish a copy of the relevant certificate, provided that there is no departure from the design so tested and approved.

Where certified flameproof equipment is not obtainable, details of the equipment are to be submitted.

Note :—

(i) A flameproof enclosure is one which will withstand without injury any explosion of the prescribed flammable gas that may occur within it under practical conditions of operation, and will prevent the transmission of flame such as will ignite the flammable gas in the surrounding atmosphere.

(ii) Intrinsically safe apparatus is to be so constructed that when installed and operated under the conditions specified by the Certifying Authority, any electrical sparking that may occur in normal working, either in the apparatus or in its associated circuit, is incapable of causing an ignition of the prescribed flammable gas or vapour.

Creepage and Clearance

110 The distances between live parts and between live parts and earthed metal whether across surfaces or in air shall be adequate for the working voltage having regard to the nature of the insulating material and the transient over-voltages developed by switch and fault conditions.

For bare busbars the following minimum clearance distances shall be observed :—

Voltage between phases or poles	Minimum clearance to earth				Minimum clearance between phases or poles			
	In air		In oil		In air		In oil	
	in.	mm.	in.	mm.	in.	mm	in.	mm.
660 or less	0·625	16	—	—	0·75	19	—	—
2200	1·5	38	—	—	1·5	38	—	—
3300	2	51	0·5	13	2	51	0·75	19
6600	2·5	63	0·75	19	3·5	89	1·0	25

Where necessary these figures are to be increased to allow for the electro-magnetic forces involved.

Emergency Source of Power

111 (*a*) In passenger ships there is to be above the bulkhead deck and outside the machinery casings a self-contained emergency source of power. The power available is to be sufficient to supply all those services necessary for the safety of passengers and crew in an emergency, due regard being paid to such services as may have to operate simultaneously. Special consideration is to be given to emergency lighting at every boat station on deck and oversides, in all alleyways, stairways and exits, in the machinery spaces and in the control stations (i.e., spaces in which radio, main navigating or central fire recording equipment or the emergency generator is located). The power is to be adequate for a period of 36 hours, except that, in ships engaged regularly on voyages of short duration a lesser supply will be specially considered. The emergency source of power may be either :—

(i) An accumulator (storage) battery capable of carrying the emergency load without recharging or excessive voltage drop; or

(ii) A generator driven by a suitable prime mover with an independent fuel supply and with satisfactory starting arrangements; the fuel used is to have a flash point of not less than 43° C. (110° F.).

(*b*) Arrangements are to be such that the emergency plant functions efficiently when the ship is inclined 22·5° and/or when the trim of the ship is 10° from an even keel.

(*c*) (i) Where the emergency power is derived from an accumulator battery arrangements are to be such that emergency lighting will automatically come into operation in the event of failure of the main lighting supply.

(ii) Where the emergency source of power is a generator there is to be a temporary source of emergency power. This is to be an accumulator battery of sufficient capacity :—

(*a*) To supply emergency lighting continuously for 30 minutes; and

(*b*) To close the watertight doors (if electrically operated), but not necessarily to close them simultaneously.

Arrangements are to be such that the temporary source of emergency power will come into operation automatically in the event of failure of the main electrical supply.

Section 2

SYSTEMS OF SUPPLY

201 The following systems of distribution may be used :—

(*a*) Parallel systems with constant pressure

DIRECT CURRENT
- Two wire
- Three wire with mid-wire earthed.

ALTERNATING CURRENT
- Single-phase—two wire
- Three phase—
  - Three wire
  - Four wire with neutral earthed but without hull return.

Systems employing single wire with hull return may be submitted for special consideration.

(*b*) Series systems with constant current (direct current only).

202 For parallel systems with constant pressure, system voltages for both alternating current and direct current shall not exceed

500 V for generation; power; cooking and heating equipment permanently connected to fixed wiring.

250 V for lighting, heaters in cabins and public rooms and other applications not mentioned above.

203 In very large alternating current installations generation and limited distribution at higher voltages (e.g., 3·3 kV) may be submitted for special consideration.

Section 3

DIVERSITY FACTOR

301 Circuits supplying two or more final subcircuits are to be rated in accordance with the total connected load subject, where justified, to the application of a diversity factor. Where spare ways are provided on a section or distribution board an allowance for future increase of load is to be added to the total connected load before application of any diversity factor.

The diversity factor may be applied to the calculation for size of cable and rating of switchgear and fusegear.

Winch Circuits

302 For winches the diversity factor is to be calculated and submitted.

Section 4

ROTATING MACHINERY

Governors

401 Where a turbine driven direct current generator is arranged to run in parallel with other generators a switch is to be fitted in each turbine emergency governor to open the generator circuit breaker when the emergency governor functions. (*See* H 436.)

402 The facilities for adjusting the governor of an alternating current generating set, at normal frequency, are to be sufficiently fine to permit an adjustment of load on the engine within 5 per cent of full load.

Number of Generators

403 The number and ratings of ship's service generating sets and converting sets are to be sufficient to ensure the operation of services essential for the propulsion and safety of the ship and preservation of the cargo even when one generating set or converting set is out of service.

Rating

404 Ship's service generators, including their exciters and continuously rated motors are to be suitable for continuous duty at their full rated output at maximum cooling air or water temperature for an unlimited period, without the limits of temperature rise in 405 being exceeded. Other generators and motors are to be rated in accordance with the duty which they are to perform and when tested under rated load conditions the temperature rise is not to exceed the values in 405.

Temperature Rise

405 Ships for Unrestricted Service

Table 4.1 gives the limits of temperature rise above the cooling air temperature for machines not fitted with water coolers and above the cooling water temperature for machines fitted with coolers, for machines intended to operate in ships classed for unrestricted service.

Ships for Restricted Service (*See* M 106)

For machines intended to operate in ships classed for restricted service as defined in M 106 the temperature rises given may be increased by 5° C. (9° F.) for all machines.

If it is known that the temperature of the cooling medium exceeds the values given in M 106 the permissible temperature rise is to be reduced by an amount equal to the excess temperature of the cooling medium.

406 The limits of temperature rise of electric slip couplings are to be in accordance with Table 4.1 except that when a squirrel cage element is used the temperature of this element is not to reach an injurious value. The temperature of the field windings is not to exceed these limits at all speeds of operation. Arrangements for reducing the excitation of self ventilated couplings at low operational speeds are permissible.

407 Alternating current machines of 5,000 h.p. or kVA output and above, and propulsion motors having a total axial core length of 1 metre or more

TABLE 4.1

TEMPERATURE RISE IN DEGREES CENTIGRADE

PART OF MACHINE		TYPE OF MACHINE								
		Not Totally Enclosed			Totally Enclosed			Fitted with Cooler		
		Class of Insulation								
		A	E	B	A	E	B	A	E	B
A.C. MACHINES										
Stator windings rated 1000 V. and above										
1. Outputs below 5000 H.P. or K.V.A. having core length less than 1 metre	R	50	60	70	50	60	70	70	80	90
2. Outputs below 5000 H.P. or K.V.A. having core length of 1 metre or more	ETD	—	60	70	—	60	70	—	80	90
3. Outputs 5000 H.P. or K.V.A. and above irrespective of core length	ETD	—	60	70	—	60	70	—	80	90
4. Stator windings rated below 1000 V.	T	40	50	60	45	55	65	65	75	85
5. Rotor windings (other than 6, 7 and 8) connected to slip rings or commutators	R	50	60	70	55	65	75	75	85	95
Salient Pole Field Windings										
6. Single layer with exposed bare surfaces	T or R	55	70	80	55	70	80	75	90	100
7. Other salient pole windings	R	50	60	70	50	65	75	70	85	95
	T	40	50	60	45	55	65	65	75	85
8. Non-salient pole field windings (turbine type generators)	R	55	70	80	55	70	80	75	90	100
9. Permanently short-circuited windings (insulated)	T	55	70	80	55	70	80	75	90	100
10. Slip rings	T	60	60	60	60	60	60	80	80	80
11. Commutators	T	55	55	55	55	55	55	75	75	75
12. Iron cores and other parts in contact with insulated windings	T	45	55	65	45	55	65	65	75	85
13. Permanently short-circuited windings, uninsulated		The temperature rise shall in no case reach such a value that there is risk of injury to any insulating material on adjacent parts								
14. Iron cores and other parts not in contact with insulated windings										
D.C. MACHINES										
15. Armature windings	T	40	50	60	45	55	65	65	75	85
	R	50	60	70	55	65	75	75	85	95
FIELD WINDINGS										
16. Single layer with exposed bare surfaces	T	55	70	80	55	70	80	75	90	100
	R	65	80	90	65	80	90	85	100	110
17. Series and commutating pole windings of more than one layer All compensating windings	T	50	65	75	50	65	75	70	85	95
	R	60	75	85	60	75	85	80	95	105
18. Shunt windings and all field windings other than 16 and 17	T	40	50	60	45	55	65	65	75	85
	R	50	60	70	50	60	70	70	80	90
19. Commutators	As item 11									
20. Slip rings	As item 10									
21. Iron cores and other parts in contact with insulated windings	As item 12									
22. Iron cores and other parts not in contact with insulated windings	As item 13									

R = measurement by resistance T = measurement by thermometer ETD = measurement by embedded temperature detector.

NOTE.—(i) Proposals to employ Class F or Class H insulation will be specially considered.
(ii) Classes of insulation are to be in accordance with I.E.C. Publication No. 85 (1957)—Recommendations for the Classification of Material for the Insulation of Electrical Machinery and Apparatus in relation to their thermal stability in service.

are to have at least three embedded temperature detectors. With multi core machines the total length is to be taken as the sum of the individual core lengths.

Overloads

408 Machines are to withstand, on test, without injury the following momentary overloads.

GENERATORS : An excess current of 50 per cent for 15 sec. after attaining the temperature rise corresponding to rated load, the terminal voltage being maintained as near the rated value as possible.

MOTORS : At rated speed or, in the case of a range of speeds, at the highest and lowest speeds, under gradual increase of torque the appropriate excess torque given below. Synchronous motors and synchronous induction motors are required to withstand the excess torque without falling out of synchronism and without adjustment of the excitation circuit preset at the value corresponding to rated load.

D.C. motors	50% for 15 sec.
Polyphase A.C. synchronous motors	50% for 15 sec.
Polyphase A.C. synchronous induction motors	35% for 15 sec.
Polyphase A.C. induction motors ...	60% for 15 sec.

The overload tests for propulsion machines will be specially considered for each installation.

Short Circuit

409 The stator and rotor windings of alternating current propulsion generators are to be capable of withstanding a momentary short circuit at the terminals of the machine applied when generating full rated voltage. Ship's service generators are to be capable of withstanding the mechanical and thermal effects of fault current for the duration of any time delay which may be fitted in a tripping device for discrimination purposes.

Insulation

410 The windings of machines for essential services are to be insulated from their frames or cores with mica or micanite or material, other than Class A, not less effective than micanite and having similar non-hygroscopic and anti-tracking properties.

Shaft Currents

411 Means are to be taken to prevent the ill effects of flow of currents circulating between the shaft and bearings.

Welding on Shafts

412 Where welding is applied to shafts of machines for securing armature arms or spiders, stress relieving is to be carried out after welding.

Brushgear

413 The final running position of brushgear is to be clearly and permanently marked.

Direct current motors and generators are to work with fixed brush setting from no load to the momentary overload specified without injurious sparking.

Alternating current commutator motors are to work over the specified range of load and speed without injurious sparking.

Direct Current Service Generators

414 Direct current generators other than those referred to in 415 are to be either

(i) compound wound

or (ii) shunt wound and operated in conjunction with an automatic voltage regulator.

415 Direct current generators used for charging batteries without series-regulating resistors are to be either

(i) shunt wound

or (ii) compound wound with switches arranged so that the series winding can be switched out of service.

416 Means are to be provided at the switchboard to enable the voltage of each generator to be adjusted separately.

For each direct current generator, coupled to its prime mover, at any temperature within the working range the means provided is to be capable of adjusting the voltage at any load between no load and full load to within :—

0·5 per cent of rated voltage for generators of rating exceeding 100 kW.

1·0 per cent of rated voltage for generators of rating not exceeding 100 kW.

417 The inherent regulation of ship's service generators is to be such that the following conditions are satisfied :—

For shunt or stabilised shunt wound generators when the voltage has been set at full load, the steady voltage at no load shall not exceed 115 per cent of the

full load value, and the voltage obtained at any intermediate value of load shall not exceed the no load value.

For compound wound generators with the generator at full load operating temperature and starting at 20 per cent load with voltage within 1 per cent of rated voltage, then at full load the voltage is to be within 2½ per cent of rated voltage. The average of the ascending and descending load curves between 20 per cent load and full load is not to vary more than 4 per cent from rated voltage.

418 Generators are to be capable of delivering continuously the full load current and normal rated voltage at the terminals when running at full load engine speed at all ambient temperatures up to the specified maximum.

419 Generators required to run in parallel are to be stable from no load up to the total combined load of the group and load sharing is to be satisfactory.

420 The series winding of each two-wire generator is to be connected to the negative terminal.

421 Equaliser connections are to have a cross sectional area appropriate to the system but in no case less than 50 per cent of that of the negative connection from the generator to the switchboard.

Alternating Current Service Generators

422 Each alternating-current service generator, unless of the self-regulated type, is to be operated in conjunction with a separate automatic voltage regulator.

423 The voltage regulation of any alternating current generator with its AVR is to be such that at all loads from zero to full load the rated voltage at rated power factor is maintained under steady conditions within $\pm 2\frac{1}{2}$ per cent.

424 In alternating current systems with one generator set out of action, the remaining set(s) are to have sufficient reserve capacity to permit the starting of the largest motor in the ship without causing any motor to stall or any other device to fail due to excessive voltage drop on the system.

425 Alternating current generators required to run in parallel are to be stable from 20 per cent full load (kW) up to the total combined full load (kW) of the group and load sharing is to be satisfactory.

426 When generators are operated in parallel the kVA loads of the individual generating sets are not to differ from their proportionate share of the total kVA load by more than 5 per cent of the rated kVA output of the largest machine when operating at 0·8 power factor.

Inspection and Testing

427 On machines for essential services tests are to be carried out and a certificate furnished by the manufacturer. The tests are to include temperature rise, momentary overload, high voltage, and commutation. The insulation resistance and the temperature at which it was measured shall be recorded. Shaft materials are to comply with Chapter P.

Generators of 100 kW or over and motors of 100 h.p. and over intended for essential services are to be inspected by the Surveyors during manufacture and testing. (A list of essential services is given in M 2002.) Shaft materials are to be tested in accordance with P 6.

428 In the case of duplicate machines up to 50 kW, kVA or b.h.p. per 1,000 r.p.m. type tests of temperature rise, excess current and torque and commutation taken on a machine identical in rating and in all other essential details may be accepted in conjunction with abbreviated tests on each machine. This is not to apply to propulsion machines. For the abbreviated tests, each machine is to be run and is to be found electrically and mechanically sound and is to have a high voltage test and insulation resistance recorded.

High Voltage Test

429 A high voltage test of 1000 V plus 2 × rated voltage with a minimum of 2000 V is to be applied to new machines preferably at the conclusion of the temperature rise test. The test is to be applied between the windings and the frame with the core connected to the frame and to any windings (or sections of windings) not under test. Where both ends of each phase are brought out to accessible separate terminals each phase is to be tested separately. The test is to be made with alternating voltage at any convenient frequency between 25 and 100 cycles per second of approximately sine wave form. The test is to be commenced at a voltage of about one-third the test voltage and is to be increased to full value as rapidly as is consistent with its value being indicated by the measuring instrument. The full test voltage is then to be maintained for one minute, and then reduced to one-third full value before switching off.

When it is desired to make additional high voltage tests on a machine which has already passed its tests the voltage of such additional tests is to be 75 per cent of the figure given above.

Motors for Refrigerated Cargo Services

430 Motors intended for coupling to fans for the circulation of air in refrigerated cargo spaces are to be inspected by the Surveyors during manufacture and testing.

Plans showing the construction of the motors are to be submitted for consideration.

Fan motors fitted in the air stream are to be totally enclosed or otherwise suitably enclosed to withstand the effects of excessive moisture where they are fitted between the two sections of a cooler or where the air from the cooler passes over the motor.

The Surveyors will witness a type test on the first motor of each size and type and works test certificates are to be supplied for the remainder. This type test may also be accepted for repeat orders of motors identical in all essential respects provided cross references are given in the works test certificates. Type tests need not be carried out for motors of the same frame size as one previously tested for higher output.

Where motors are mounted in the air stream but are to be tested in still air conditions generally two conditions arise:—

(i) The motor may be open at one end or both ends when tested but totally enclosed when mounted in the air stream. In such cases a type test should be carried out under working conditions, i.e., in the trunking with the fan and fairings in place or alternatively, calculations furnished to show that the Rules for temperature rise are complied with.

(ii) The motor may be totally enclosed but with streamlined fairings. These may be accepted if, when tested in still air, the temperature rises are within the requirements of the Rules for totally enclosed motors. If they are outside these requirements the procedure in (i) is to be followed.

Electric Slip Couplings

431 Slip couplings are to be inspected by the Surveyors during manufacture and testing. Unless otherwise approved, every coupling is to be tested at the makers' works, the tests to include:—

Temperature rise test
Determination of magnetic centre
High voltage test

Insulation resistance is to be recorded and the temperature at which it was measured.

Section 5

DISTRIBUTION

Final Sub-Circuits

501 A final sub-circuit of rating exceeding 15A is not to supply more than one point. The number of lighting points supplied by a final sub-circuit of rating 15A or less is not to exceed:—

for	24 — 55 V	circuits	10
„	110 — 127 V	„	14
„	220 — 250 V	„	18

except that in final sub-circuits for cornice lighting, panel lighting and electric signs where lampholders are closely grouped the number of points supplied is unrestricted provided the maximum operating current in the sub-circuit does not exceed 10A.

502 A separate final sub-circuit is to be provided for every motor required for essential services.

503 Lighting circuits are to be supplied by final sub-circuits separate from those for heating and power. (This does not apply to cabin fans and wardrobe heaters.)

504 Lighting of cargo spaces and coal bunkers is to be controlled by multi-pole linked switches situated outside these spaces. Provision is to be made for the complete isolation of these circuits and locking in the off position of the means of control.

Navigation Lights

505 Navigation lights are to be connected separately to a distribution board reserved for this purpose only, and connected directly or through transformers to the main or emergency switchboard. The distribution board is to be accessible to the officer of the watch.

Each navigation light is to be controlled and protected in each insulated pole by a switch and fuse or circuit breaker mounted on the distribution board.

Where the navigation panel is situated in the midships house, the midships sub-switchboard is regarded as an extension of the main switchboard providing it is supplied from the main switchboard by two cables each capable of carrying full load.

Each navigation light is to be provided with an automatic indicator giving aural and/or visual indication of failure of the light. If an aural device alone is fitted it is to be connected to a primary or secondary battery. If a visual signal is used connected in series with the navigation light means are to be provided to prevent extinction of the navigation light due to failure of the signal. The requirements of this paragraph do not apply to tugs, trawlers, fishing and similar small vessels.

Provision is to be made on the bridge for such navigation lights to be transferred to an alternative circuit.

Any statutory requirements of the country of registration are to be complied with and may be accepted as an alternative to the above.

Steering Gear

506 Where the steering gear is operated by two independent mechanisms and electric power is used for the operation of both, the power shall be supplied by two sets of cables both from the main switchboard, or one set of cables may be connected to an emergency switchboard having ship's service and emergency feeds. Each set of cables shall be separated throughout their length as widely as practicable. Only short circuit protection and an overload alarm, shall be provided on steering-gear circuits.

Fire Extinguishing Systems

507 Where electrically driven emergency fire pumps are installed in accordance with F 114, the supply to such pumps is not to pass through the main machinery spaces.

There are to be not less than two sources of power supply for sea water pumps, air compressors and automatic alarms used in conjunction with automatic sprinkler systems. One supply is to be taken via the emergency switchboard by a feeder reserved solely for this purpose. No switch is to be fitted in this circuit other than that at the switchboard and a changeover switch (if fitted).

Heating and Cooking

508 Each item of heating or cooking equipment is to be controlled as a complete unit by a multi-pole linked switch mounted in the vicinity of the equipment. In the case of cabin heaters a single pole switch will be acceptable.

Shore Supply

509 (*a*) Where arrangements are made for the supply of electricity from a source on shore or elsewhere a suitable connection box is to be installed in a position in the ship suitable for the convenient reception of flexible cables from the external source and containing a circuit breaker or isolating switch and fuses and terminals of ample size and suitable shape to facilitate a satisfactory connection. Suitable cables, permanently fixed, are to be provided, connecting the terminals to a linked switch and/or a circuit breaker at the main switchboard.

(*b*) For three-phase shore supplies with earthed neutral an earth terminal is to be provided for connecting the hull to the shore earth.

(*c*) The shore connection is to be provided with an indicator at the main switchboard in order to show when the cable is energised.

(*d*) Means are to be provided for checking the polarity (for direct current) or the phase sequence (for three-phase alternating current) of the incoming supply in relation to the ship's system.

(*e*) At the connection box a notice is to be provided giving full information on the system of supply and the normal voltage (and frequency if alternating current) of the ship's system and the procedure for carrying out the connection.

(*f*) Alternative arrangements may be submitted for consideration.

Submersible Bilge Pumps

510 Motors of permanently installed submersible bilge pumps are to be connected to the emergency switchboard (if fitted).

Cables and their connections to such pumps are to be capable of operating under a head of water equal to their distance below the bulkhead deck. The cables are to be suitable for operation in permanently wet situations, and installed in continuous lengths from above the bulkhead deck to the motor terminals.

Under all circumstances it is to be possible to start the motor of a permanently installed submersible bilge pump from a position above the bulkhead deck.

Section 6

SWITCHBOARDS, SWITCHGEAR AND PROTECTIVE EQUIPMENT

Switchboards

601 (*a*) An unobstructed space is to be left in front of switchboards. Pipes should, as far as possible, not be installed directly above or in front of or behind switchboards. If such placing is unavoidable suitable protection is to be provided in these positions. (*See* E 275.)

(*b*) Where necessary the space at the rear of switchboards is to be ample to permit maintenance and in general not less than 24 in. (0,6 m.) except that this may be reduced to 18 in. (0,5 m.) in way of stiffeners or frames.

(*c*) For voltages between poles or to earth above 150 V alternating current or 250 V direct current dead front switchboards are to be used. Where live parts on a switchboard are adjacent to a gangway an insulated handrail is to be provided.

(*d*) Section and distribution boards are to be suitably enclosed unless they are installed in a cupboard or compartment to which only authorised persons have access. The enclosure is to be of non-hygroscopic and non-flammable material and in accommodation spaces where the enclosure may be surrounded by flammable material a layer of non-hygroscopic non-flammable material which is also thermal insulating is to be provided.

(*e*) All measuring instruments and all apparatus controlling circuits are to be clearly and indelibly labelled for identification purposes. An indelible label is to be permanently secured to, or adjacent to, every fuse and every circuit breaker and marked with particulars of the full load current of the generator or cable which the fuse or circuit breaker protects. The labels for rewirable fuses are also to be marked with the appropriate size of fuse element. Where inverse time limit and/or reverse current devices are provided in connection with a circuit breaker, the appropriate settings of these devices are to be stated on the label. Nameplates are to be of flame-retardant material.

Busbars

602 Busbars and their connections are to be of copper, all connections being made so as to inhibit corrosion. Busbars and their supports are to be so designed as to withstand the mechanical stresses which will arise during short circuits. The maximum permissible temperature rise for bare conductors is 45° C. (81° F.).

Equaliser Connections

603 The current rating of equaliser connections and equaliser switches is to be not less than half the rated full load current of the generator. The current rating of equaliser busbars is to be not less than half the rated full load current of the largest generator in the group.

Instruments for Direct Current Generators

604 (*a*) For generators not operated in parallel at least one voltmeter and one ammeter are to be provided for each generator.

(*b*) For parallel operation one ammeter is to be provided for each generator, and two voltmeters. One voltmeter is to be connected to the busbars and the other is to be capable of measuring the voltage of any generator.

(*c*) For compound wound generators fitted with equaliser connections the ammeter is to be connected to the pole opposite to that connected to the series winding of the generator.

(*d*) For three-wire generators the ammeter is to be located between the equaliser connection and the generator.

(*e*) For three-wire systems supplied by a three-wire generator or by a balancing booster an ammeter is to be connected to each outer pole of each balancing generator and a voltmeter between each pole of the busbars and the middle wire.

Instruments for Alternating Current Generators

605 (*a*) For alternating current generators not operated in parallel each generator is to be provided with at least one voltmeter, one frequency meter and one ammeter with an ammeter switch to enable the current in each phase to be read or an ammeter in each phase and for generators above 50 kVA a wattmeter.

(*b*) For alternating current generators operated in parallel each generator is to be provided with a wattmeter, and an ammeter in each phase conductor or an ammeter with a selector switch to permit the measuring of current in each phase.

For paralleling purposes two voltmeters, two frequency meters and a synchronising device comprising either a synchroscope and lamps, or an

equivalent arrangement, are to be provided. One voltmeter and one frequency meter are to be connected to the busbars, the other voltmeter and frequency meter are to be switched to enable the voltage and frequency of any generator to be measured.

Instrument Scales

606 (*a*) The upper limit of the scale of every voltmeter is to be approximately 120 per cent of the normal voltage of the circuit and the normal voltage is to be clearly indicated.

(*b*) The upper limit of the scale of every ammeter is to be approximately 130 per cent of the normal rating of the circuit in which it is installed. Normal full load is to be clearly indicated.

(*c*) Ammeters for use with direct current generators and kW meters for use with alternating current generators which may be operated in parallel are to be capable of indicating 15 per cent reverse current or power respectively.

Earth Indication

607 Every insulated distribution system is to be provided with lamps or other means to indicate the state of insulation from earth.

Protection

608 Installations are to be protected against accidental overcurrents including short-circuit. The protective devices are to provide complete and co-ordinated protection to ensure :—

(i) Continuity of service under fault conditions through discriminative action of the protective devices.

(ii) Elimination of the fault so as to reduce damage to the system and hazard of fire.

Protection against Overload

609 Circuit-breakers and automatic switches provided for overload protection are to have tripping characteristics appropriate to the system. Fuses above 320A are not to be used for overload protection, but may be used for short-circuit protection.

Over-current releases of circuit-breakers for generators and for circuits with preference tripping are to be adjustable.

NOTE.—Overload is considered to be an over-current in a circuit in which the insulation is still effective. Short circuit is considered to be an over-current in a circuit in which the insulation is defective.

Protection against Short Circuit

610 Protection against short-circuit currents is to be provided by circuit-breakers or fuses. In the case of three-phase motor circuits, either circuit-breakers, or an appropriate combination of an automatic switch and fuses is to be used.

The breaking capacity of every protective device is to be not less than the maximum value of the short-circuit current which can flow at the point of installation at the instant of contact separation.

The making capacity of every circuit-breaker or switch intended to be capable of being closed, if necessary, on short-circuit, is to be not less than the maximum value of the short-circuit current at the point of installation. On alternating current this maximum value corresponds to the peak value allowing for maximum asymmetry.

Every protective device or contactor not intended for short-circuit interruption is to be adequate for the maximum short-circuit current which can occur at the point of installation having regard to the time required for the short-circuit to be removed.

In the absence of precise data the following short-circuit currents at the machine terminals are to be assumed :—

D.C. SYSTEMS

Ten times full load current for generators normally connected (including spare).

Six times full load current for motors simultaneously in service.

A.C. SYSTEMS

Ten times full load current for generators normally connected (including spare)—symmetrical RMS.

Three times full load current for motors simultaneously in service.

Combined Circuit-Breakers and Fuses

611 The use of a circuit-breaker of breaking capacity less than the prospective short-circuit current at the point of installation is permitted provided that it is preceded on the generator side by fuses, or by a circuit-breaker having at least the necessary breaking capacity. The generator breakers are not to be used for this purpose.

Fused circuit-breakers with fuses connected to the load side may be used where operation of the circuit-breaker and fuses is co-ordinated.

The characteristics of the arrangement shall be such that :—

(i) When the short-circuit current is broken the circuit-breaker on the load side shall not be damaged and is to be capable of further service.

(ii) When the circuit-breaker is closed on the short-circuit current the remainder of the installation shall not be damaged. It is, however, admissible that the circuit-breaker on the load side may require servicing after the fault has been cleared.

Protection of Circuits

612 Short-circuit protection is to be provided in each live pole of a direct-current system and in each phase of an alternating-current system.

Overload protection is to be provided in :—

Two-wire d.c. or single-phase a.c. system—at least one line or phase.

Three-wire d.c. system—both outer lines.

Insulated three-phase a.c. system—at least two phases.

Earthed three-phase a.c. system—all three phases.

No fuse, non-linked switch or non-linked circuit-breaker is to be inserted in an earthed conductor. Any switch or circuit-breaker fitted is to operate simultaneously in the earthed conductor and the insulated conductors.

These requirements do not preclude the provision (for test purposes) of an isolating link to be used only when the other conductors are isolated.

Protection of Generators

613 In addition to over-current protection the following protective gear is to be provided as a minimum :—

(*a*) For generators not arranged to run in parallel : A circuit-breaker arranged to open simultaneously all insulated poles or in the case of generators rated at less than 50 kW a multi-pole-linked switch with a fuse in each insulated pole.

(*b*) For generators arranged to operate in parallel : A circuit-breaker arranged to open simultaneously all insulated poles. This circuit-breaker is to be provided with :—

(i) For direct-current generators, instantaneous reverse-current protection operating at not more than 15 per cent rated current.

(ii) For alternating-current generators a reverse-power protection, with time delay, selected and set within the limits of 2 per cent to 15 per cent of full load to a value fixed in accordance with the characteristics of the prime mover.

The reverse-current protection is to be adequate to deal with the reverse-current conditions emanating from the ship's network, e.g., cargo winches. The reverse-power protection specified for alternating-current generators may be replaced by other devices ensuring adequate protection of the prime movers.

(*c*) In addition the following is to be provided for direct-current generators arranged to operate in parallel.

(i) Where an equaliser connection is in use the reverse-current protection is to be provided in the pole opposite to that in which the series winding is connected.

(ii) For compound generators an equaliser switch for each generator so interlocked that it closes before and opens after the main contacts of the circuit-breaker with which it is associated, or a three-pole circuit-breaker with all poles operating simultaneously.

(iii) In three-wire systems a switch in the connection to the middle wire so interlocked with the generator switch or circuit-breaker connected to the outers as to operate simultaneously with them.

Essential Services

614 Where generators are operated in parallel and essential machinery is electrically driven arrangements are to be made to disconnect automatically the excess non-essential load when the generators are overloaded.

If required this load shedding may be carried out in one or more stages.

Circuits for cargo refrigeration machinery are to be included in the last group to be disconnected.

Power Transformers

615 The primary circuits of power transformers are to be protected against short-circuit by circuit-breakers or fuses.

When transformers are arranged to operate in parallel means of isolation are to be provided on the secondary windings. Switches and circuit-breakers are to be capable of withstanding surge currents.

Feeder Circuits

616 For each main distribution circuit protection is to be ensured by multi-pole circuit-breaker or switch and fuses in accordance with 609, 610 and 613. This does not apply to steering-gear circuits which are to have short-circuit protection only, and overload alarm. The protective devices are to allow excess current to pass during the normal accelerating period of motors.

Circuits which supply motors fitted with overload protection may be provided with short-circuit protection only.

Motors of rating exceeding 0·5 kW/h.p. and all motors for essential services are to be protected individually against overload and short-circuit. The short-circuit protection can be provided by the same protective device for the motor and its supply cable. For essential motors which are duplicated the overload protection may be replaced by an overload alarm if desired by the owner.

For motors intended to provide uninterrupted service the protective gear is to have a delay characteristic to enable the motor to start, yet which will operate on overload before the windings reach an unacceptably high temperature. The current which the protective device will allow to pass indefinitely is not to exceed 125 per cent of the rated current.

For motors for intermittent service the current setting and the delay is to be chosen in relation to the load factor of the motor.

Lighting circuits are to be provided with overload and short-circuit protection.

Meters, Pilot Lamps, Capacitors

617 Protection is to be provided for voltmeters, voltage coils of measuring instruments, earth indicating devices and pilot lamps together with their connecting leads.

A pilot lamp installed as an integral part of another item of equipment need not be individually protected, provided it is fitted in the same enclosure. Pilot lamps are not to be subjected to a higher voltage than 250 V to earth. Where a fault in a pilot lamp would jeopardise the supply to essential equipment such lamps are to be individually protected.

Where capacitors, for suppression of radio interference are fitted to busbars, generators, or steering-gear fuses of appropriate size are to be connected in the capacitor circuit.

Switchgear

618 (*a*) Circuit-breakers and switches are to be of the air break type.

(*b*) The limits of temperature rise are to be based on the cooling air temperatures given in Section 1, and when measured by thermometer or thermocouple are not to exceed :—

Contacts : Solid copper ...	40° C.	(72° F.)
Silver or similar	65° C.	(117° F.)
Bare conductors and connections	45° C.	(81° F.)
Coils : Class A insulation ...	50° C.	(90° F.)
Class E insulation ...	65° C.	(117° F.)
Class B insulation ...	80° C.	(144° F.)

(*c*) Reports of tests to establish the capacity of circuit-breakers are to be submitted for consideration when required.

(*d*) Each circuit opening device is to be so arranged that when placed in the OFF position it cannot accidentally move so as to close the circuit.

(*e*) Circuit-breakers are to be of the trip free type.

(*f*) The over-current releases of circuit-breakers for generators and the setting of preference tripping relays are to be adjustable.

(*g*) Where reverse-power or reverse-current protection is provided it is to be adjustable to the circumstances of reverse-power between the limits of 2 per cent and 15 per cent of full load that may be expected. (*See* 613(b).)

(*h*) A fall of 50 per cent in the applied voltage shall not render the reverse-current mechanism inoperative although it may alter the amount of reverse-current required to open the breaker.

(*i*) Over-current releases are to be calibrated in amperes, and the settings marked on the circuit-breaker.

(*j*) Handles and operating mechanisms are to be so arranged that the hand of the operator cannot accidentally touch live metal or be injured through an arc arising from the switch or circuit breaker, or the rupturing of a fuse. If switches are enclosed their handles are not to operate through unprotected slots.

Testing

619 Before installation, switchboards complete or in sections with all components are to pass the following tests at the manufacturers' works and a certificate furnished. A high voltage test is to be carried out on all switching and control apparatus for systems greater than 60 V with a test voltage of

1,000 V plus twice the rated voltage (minimum 2,000 V) at any frequency between 25 c/s and 100 c/s for one minute applied between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase.

For systems of 60 V or less the test shall be at 500 V for one minute.

Immediately after the high voltage test the insulation resistance between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase, shall be not less than 1 megohm when tested with a d.c. voltage of at least 500 V.

Instruments and ancillary apparatus may be disconnected during the high voltage test.

Fuses

620 Fuses are to comply with an approved national standard or with the recommendations of the International Electrotechnical Commission and with the following clauses.

The breaking capacity of the fuse is to be not less than the prospective short-circuit current at the point of installation.

Fuses are to be suitable for operating in the ambient temperatures given in M 106 and the temperature rise at the terminals is to be such that the maximum permissible temperature(s) of the connected cable(s) is not exceeded.

621 Fuse-links and fuse-bases are to be marked with particulars of rated current and rated voltage. Each fuse position is to be permanently and indelibly labelled with the current carrying capacity of the circuit protected by it and with the appropriate approved size of fuse or replaceable element.

622 A list of approved fuses will be issued. To secure approval a report, preferably by an independent authority, is to be submitted giving details of test performance, fusing characteristics, temperature and insulation tests and details of the specification to which the fuse has been tested. Outline drawings are to be included but samples should not be submitted unless requested.

Section 7

CONTROL GEAR

701 The limits of temperature rise for control gear are to be based on the cooling air temperatures given in M 106.

The temperature rise, at full rated load, measured by thermometer or thermocouple is not to exceed :—

Contacts : Solid copper ...	60° C.	(108° F.)
Silver or similar ...	75° C.	(135° F.)
Bare conductors and connections	45° C.	(81° F.)
Coils : Class A insulation ...	60° C.	(108° F.)
Class E insulation ...	75° C.	(135° F.)
Class B insulation ...	90° C.	(162° F.)

Iron cores in contact with coils—temperature rise as for coils.

Iron cores not in contact with coils—temperature rise to be such that neither the cores nor adjacent parts are damaged.

Resistors—maximum operating temperatures shall not exceed 410° C.

Other parts whether insulated or not are not to reach a temperature which might harm the parts themselves or materials with which they are in contact.

702 Control gear, including isolating and reversing switches is to be so arranged that shunt field circuits are not disconnected without an adequate discharge path being provided.

703 Every electric motor is to be provided with efficient means of starting and stopping so placed as to be easily operated by the person controlling the motor. Every motor above 0·5 kW/h.p. is to be provided with the following control apparatus :—

(*a*) Means to prevent undesired restarting after a stoppage due to low volts or complete loss of volts. This does not apply to motors, the continuous availability of which is essential to the safety of the ship.

(*b*) Efficient means of isolation are to be provided so that all voltage may be cut off from the motor and any associated apparatus including any automatic circuit-breaker.

Where the primary means of isolation (that provided at the switchboard, section board or distribution fuse board) is remote from a motor, one of the following is to be provided :—

(i) An additional means of isolation fitted adjacent to the motor.

or (ii) Provision made for locking the primary means of isolation in the OFF position.

or (iii) Provision made so that the fuses in each line can be readily removed and retained by authorised personnel.

(*c*) Means for automatic disconnection of the supply in the event of excess current due to mechanical overloading of the motor (this does not apply to steering motors). (*See also* M 616.)

(*d*) Where fuses are used to protect polyphase motor circuits, means are to be provided to protect the motor against unacceptable overload in the case of single phasing.

704 When selecting motor control gear the maximum current of a motor is to be taken as the full load rated current of the motor.

705 Where a single master-starter system (e.g., a starter used for controlling a number of motors successively) is used the apparatus is to provide under-voltage and over-current protection and means of isolation for each motor not less effective than that required for systems using a separate starter for each motor. Where the starter is of the automatic type, suitable alternative means are to be provided for manual operation. Where the starter is used for motors for essential services the starting portion shall be duplicated and means are to be provided for the transfer of the starting duties in the event of failure of one of the starters.

706 Means are to be provided for stopping ventilating fans serving machinery and cargo spaces. These means are to be capable of being operated from outside such spaces in case of fire.

Machinery driving forced and induced draught fans, oil fuel transfer pumps, oil fuel unit pump and other similar fuel pumps are to be fitted with remote controls situated outside the space concerned so that they may be stopped in the event of fire arising in the space in which they are located.

In passenger ships carrying more than 36 passengers all power ventilation systems, except cargo and machinery space ventilation, are to be fitted with master controls so that all fans may be stopped from either of two separate positions which are to be situated as far apart as practicable.

707 Control gear and resistors are to be tested by the makers with a high voltage applied between the earthed frame and all live parts. The test voltage is to be 1,000 V plus twice the rated voltage with a minimum of 2,000 V. The voltage is to be alternating at any frequency between 25 and 100 c/s and is to be maintained for one minute without failure.

Immediately after the high voltage test the insulation resistance between (i) all current-carrying parts connected together and earth and (ii) between current-carrying parts of opposite polarity or phase, shall be not less than 1 megohm when tested with a direct current voltage of at least 500 V. Instruments and auxiliary apparatus may be disconnected during the high voltage test.

Section 8

CABLES

Conductors

801 High conductivity annealed copper only is to be used. For rubber-insulated cables the copper wire is to be tinned or alloy coated and the surface is to be bright.

Conductor composition and stranding is to be selected so that adequate flexibility of the finished cable is assured. Conductors of nominal cross section 0·003 sq. in. (2,5 sq. mm.) and less need not be stranded. This requirement does not apply to mineral-insulated cables which have solid conductors. Cores of multi-core cables are to be readily identifiable.

Insulating Materials

802 The following insulating materials are permitted:—

TABLE 8.1

Insulating Material	Maximum rated conductor Temp. °C.	Maximum Ambient Temp. °C.
Natural or synthetic rubber (general purpose)	60	50
Polyvinyl chloride compound (general purpose)	60	50
Natural or synthetic rubber (heat resisting)	75	65
Varnished cambric, Butyl ...	80	70
Asbestos-varnished cambric ...	85	75
Silicone rubber	95	—
Mineral...	95	—

NOTE.—Silicone rubber and mineral insulation may be used for higher temperatures when installed where they are not liable to be touched by ship's personnel viz. silicone rubber 150° C. mineral unlimited. Proposals to employ these higher temperatures will be specially considered.

Where a rubber or rubber-like material with maximum conductor temperature greater than 60° C. is used it is to be readily identifiable.

Other insulating materials will be considered.

Insulation

803 (*a*) RUBBER—The use of a single layer is permitted only when applied by the extrusion process. With other processes the insulation is to consist of at least two layers of rubber compound equal or different in quality (including polychloroprene compound but not pure rubber). The layers are to be bonded together.

The insulating wall is to be close fitting, but not adherent to the conductor.

(*b*) POLYVINYLCHLORIDE—Polyvinylchloride insulation is to be applied by extrusion in one or more layers, is to be close fitting but not adherent to the conductor.

(*c*) VARNISHED CAMBRIC—Varnished cambric is to consist of a closely woven cloth tape uniformly coated on both sides with an insulating varnish. The average thickness of the finished cloth is to be not less than 5 mils (0,13 mm.) nor more than 13 mils (0,33 mm.).

The insulating wall is to consist of several layers of varnished cambric tape, applied helically and smoothly, with or without overlapping, each tape covering the gap, if any, of the underlying tape.

An insulating and lubricating compound is to be applied between the layers of varnished cloth so as to exclude air and moisture.

If a binder or identification tape is used and is made of insulating material it may be considered as part of the insulating wall.

(*d*) ASBESTOS-VARNISHED CAMBRIC—The insulation of each conductor is to consist of a layer of felted asbestos, impregnated with heat and moisture resisting compound, plus layers of varnished cambric tape plus a layer of impregnated-felted asbestos. In place of felted asbestos, asbestos roving, glass roving, asbestos tape or glass tape may be used.

(*e*) MINERAL INSULATION—Mineral insulation is to consist of a powdered mineral material, e.g., magnesium oxide, highly compressed between conductors and copper sheath. It is to be temperature-stable and non-corrosive to copper.

Construction

804 Whatever the insulating material used both the belted and non-belted construction may be used for two, three and more conductor cables.

Non-belted Cables

805 For non-belted cables the spaces among the cores are to be filled with fibrous or rubber-like fillers and the cylindrical assembly is to be sheathed with the appropriate protective covering. Fillers may be omitted in multi-core cables having conductor sections 0·007 sq. in. (4,5 sq. mm.) or less.

Belted Cables

806 Belted cables are to be constructed as non-belted cables except that an insulating wall is to be applied to the cabled cores before applying the protective covering. For rubber or PVC-insulated cables the common belt is to be rubber or PVC respectively which may or may not form one body with the fillers.

Fillers

807 When fibrous fillers are used they are to consist of jute or similar rovings (including asbestos, glass, &c.), and are to be resistant to moisture.

When rubber-like fillers are used they are to consist of rubber (including regenerated and/or unvulcanized rubber) compounds or plastic compounds.

Sheaths and Protective Coverings

808 Cables are to be protected by one or more of the following and the sheath or protective covering is to be compatible with the insulation :—

SHEATH	Lead-alloy sheath
	Copper sheath
	Non-metallic sheath
PROTECTIVE COVERING	Steel-wire armour
	Steel-tape armour
	Metal-braid armour (basket weave)
	Fibrous braid

Unsheathed cables, e.g., rubber-insulated taped and braided or equivalent may be used only if installed in conduit.

(*a*) LEAD-ALLOY SHEATH—This is to be one of the recommended lead alloys given in I.E.C. Publication 92.

(*b*) COPPER—Copper sheath is permitted only for mineral-insulated cables.

(*c*) METAL-BRAID ARMOUR (Basket weave)—This is to be formed of galvanized steel, copper or copper alloy or aluminium alloy wires. Aluminium alloy is to be corrosion-resistant. The coverage density of the braid is to be such that the weight of the braid

is at least 90 per cent of the weight of a tube of the same metal having an internal diameter equal to the internal diameter of the braid and a thickness equal to the diameter of one of the wires forming the braid.

(*d*) STEEL-WIRE ARMOUR—This is to consist of galvanized-annealed-steel wires having an elongation at break of at least 12 per cent. The wires are to be applied over the bedding so as to form a uniformly cylindrical layer and so as to ensure adequate flexibility for the cable.

(*e*) STEEL-TAPE ARMOUR—This is to consist of annealed-steel tape. In general the armour is to be formed of two tapes wound over the bedding in the same direction so that the gap in the first layer is not more than half the tape width and the second layer covers this gap with an overlap.

NOTE.—Armour is to be protected against corrosion where necessary. A protective bedding is to be inserted beneath armour (of any type). This may be textile tape or braid, PCP tape or other suitable material. Textile materials are to be treated against moisture.

(*f*) NON-METALLIC SHEATH—Polychloroprene compound and polyvinylchloride compound may be used for impervious sheaths. PVC sheaths are not to be applied direct to rubber insulated cables. For asbestos-varnished cambric cables, asbestos sheath is permissible.

(*g*) FIBROUS BRAID—Textile braid is to be of cotton, hemp, asbestos, glass, or other equivalent fibre and is to be of strength suitable for the size of the cable. It is to be effectively impregnated with a compound which is resistant to moisture, and flame retarding except where flame-extending cables are permitted by 812.

Dimensions

809 The thickness of insulation and sheath is to be generally in accordance with Tables 8.2 and 8.3.

The cables may be used in circuits in which the voltage between a conductor and the hull of the ship does not exceed the voltage at the head of the appropriate Table. In an insulated system the voltage between any conductor and the hull of the ship is assumed to be equal to the voltage between lines.

250 V cables may be used for any conductor of a three-phase, 440 V, alternating-current system with star point earthed.

Cables with other dimensions but which comply with a national specification for marine cables may be submitted for consideration.

Choice of Cables

810 The rated voltage of any cable is to be not lower than the nominal voltage of the circuit for which it is used.

Cables exposed to voltage surges associated with highly inductive circuits, e.g., contactor operating circuits for winches, etc., are to be at least 660 V grade.

The rated operating temperature of the insulating material is to be at least 10° C. (18° F.) higher than the maximum ambient temperature liable to be produced in the space where the cable is installed.

Polyvinylchloride insulation is not to be used where it is necessary for the cable to pass through watertight bulkhead glands. (*See also* 842.) Its use is to be restricted to the smaller sizes of cables (in general up to ·06 sq. in. or 35 sq. mm.).

Choice of Protective Covering

811 Cables fitted in the following locations :—

Decks exposed to the weather
Bathrooms
Cargo holds
Refrigerated spaces
Machinery spaces

or in any other location where water condensation or harmful vapour (e.g., oil vapour) may be present are to have an impervious sheath. In permanently wet situations metallic sheaths are to be used for cables with hygroscopic insulation.

812 All cables are to be of flame-retardant or fire-resisting types (*see* 850) except that flame-extending cables may be used for final circuits only in the following cases :—

(*a*) Where cables are installed in metallic conduits having an internal diameter not exceeding 1 in. (25 mm.) and provided the conduits are mechanically and electrically continuous.

(*b*) Bare lead sheathed cable having conductor sections not exceeding 0·007 sq. in. (4,5 sq. mm.).

Current Rating

813 The highest continuous load carried by a cable is not to exceed its current rating. The diversity factor of the individual loads and the duration of the maximum demand may be allowed for in estimating the maximum continuous load and is to be shown on plans submitted for approval.

TABLE 8.2

THICKNESS OF INSULATION

Nominal cross section			Rubber		P.V.C.		Varnished Cambric			Asbestos-Varnished Cambric				Mineral	
			250 V.	660 V.	250 V.	660 V.	1100 V.		3300 V.	250 V.		660 V.		440 V.	660 V.
			Radial	Radial	Radial	Radial	c/c	c/s	c/c; c/s	Radial Cambric	Radial Asbestos	Radial Cambric	Radial Asbestos	c/c; c/s	c/c; c/s
	sq. in.	sq. mm.	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*	in. *mm.*
1/·044	·0015		·030	·055	·025	·035	·070	·055	·130	·018	·020	·030	·030	·040	·060
		1	*0,8*	*1,4*	*0,6*	*0,9*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
3/·029	·002		·030	·055	·025	·035	·070	·055	·130	·018	·020	·030	·030	·040	·060
		1,5	*0,8*	*1,4*	*0,6*	*0,9*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
3/·036; 1/·064	·003		·030	·055	·025	·035	·070	·055	·130	·018	·020	·030	·030	·040	·060
		2,5	*0,8*	*1,4*	*0,6*	*0,9*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
7/·029	·0045		·030	·055	·025	·035	·070	·055	·130	·018	·020	·030	·030	·040	·060
		4	*0,9*	*1,5*	*0,6*	*1,0*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*	*1,0*	*1,5*
7/·036	·007		·035	·060	·030	·040	·070	·055	·130	·018	·020	·030	·030	·040	·060
		6	*0,9*	*1,5*	*0,8*	*1,0*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
7/·044	·01		·035	·060	·030	·040	·070	·055	·130	·018	·020	·030	·030		·060
7/·052	·0145		·040	·060	·035	·040	·070	·055	·130	·018	·020	·030	·030		·060
		10	*1,0*	*1,5*	*0,9*	*1,0*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
7/·064	·0225		·040	·060	·035	·040	·070	·055	·130	·018	·020	·030	·030		·060
		16	*1,0*	*1,5*	*0,9*	*1,1*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
19/·044	·03		·045	·060	·040	·045	·070	·055	·130	·018	·020	·030	·030		·060
		25	*1,2*	*1,6*	*1,0*	*1,3*	*1,8*	*1,4*	*3,3*	*0,45*	*0,5*	*0,8*	*0,8*		*1,5*
19/·052	·04		·050	·065	·045	·050	·070	·055	·130	·018	·025	·030	·030		·060
		35	*1,4*	*1,6*		*1,3*	*1,8*	*1,4*	*3,3*	*0,45*	*0,6*	*0,8*	*1,2*		*1,5*
19/·064	·06		·055	·065		·050	·070	·055	·130	·018	·025	·030	·045		·060
		50		*1,7*			*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
		60		*1,7*			*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
19/·083	·1			·070			·070	·055	·130			·030	·045		·060
		70		*1,8*			*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
		95		*2,0*			*1,8*	*1,4*	*3,3*			*0,8*	*1,2*		*1,5*
37/·072	·15			·080			·070	·055	·130			·030	·045		·060
		120		*2,3*			*1,8*	*1,4*	*3,3*			*0,8*	*1,9*		*1,5*
37/·083	·2			·090			·070	·055	·130			·030	·075		·060
		150		*2,4*			*1,8*	*1,4*	*3,3*			*0,8*	*1,9*		*1,5*
37/·093	·25			·095			·070	·055	·130			·030	·075		·060
		185		*2,5*			*1,8*	*1,4*	*3,3*			*0,8*	*1,9*		*1,5*
37/·103	·3			·100			·070	·055	·130			·030	·075		·060
		240		*2,7*			*1,9*	*1,5*	*3,3*			*0,8*	*1,9*		*1,5*
61/·093	·4			·110			·080	·065	·130			·030	·075		·060
		300		*3,0*			*2,0*	*1,6*	*3,3*			*0,8*	*1,9*		*1,5*
61/·103	·5			·120			·080	·065	·130			·030	·075		·060
		400		*3,2*			*2,0*	*2,0*	*3,3*			*0,8*	*1,9*		*1,5*
91/·103	·75			·130			·090	·080	·130			·030	·075		·060
		500		*3,3*			*2,3*	*2,0*	*3,3*			*0,8*	*1,9*		*1,5*
		625		*3,5*			*2,5*	*2,3*	*3,3*			*0,8*	*1,9*		*1,5*
127/·103	1·0			·140			·100	·090	·130			·030	·075		·060

c/c = between conductors c/s = between conductor and sheath.

NOTE.—Rubber and P.V.C. thicknesses are the average of a number of measurements.
Tolerance on declared values:— Rubber 5%+·005 in. (0,13 mm.) P.V.C. up to ·050 in. (1,3 mm.) 5%+·003 in. (0,076 mm.).

TABLE 8.3

THICKNESS OF SHEATH

Diameter under Sheath		Thickness of Sheath (Average)		
Above	Up to and including	Rubber or P.C.P.	P.V.C.	Lead Alloy
in. *mm.*	in. *mm.* 0·25 *6,0*	in. *mm.* ·040 *1,0*	in. *mm.* ·035 *0,9*	in. *mm.* ·040 *1,0*
·25 *6,0*	·5 *12,0*	·050 *1,3*	·045 *1,15*	·045 *1,15*
·5 *12,0*	·75 *19,0*	·060 *1,5*	·055 *1,4*	·055 *1,4*
·75 *19,0*	1·0 *25,0*	·070 *1,8*	·070 *1,8*	·065 *1,65*
1·0 *25,0*	1·25 *31,0*	·080 *2,0*	·080 *2,0*	·075 *1,9*
1·25 *31,0*	1·5 *38,0*	·090 *2,3*	·090 *2,3*	·085 *2,15*
1·5 *38,0*	1·75 *44,0*	·100 *2,5*	·100 *2,5*	·095 *2,4*
1·75 *44,0*	2·0 *51,0*	·110 *2,8*	·110 *2,8*	·105 *2,65*
2·0 *51,0*	2·25 *57,0*	·120 *3,0*	·120 *3,0*	·115 *2,9*
2·25 *57,0*	2·5 *63,0*	·130 *3,3*	·130 *3,3*	·125 *3,15*
2·5 *63,0*	2·75 *70,0*	·140 *3,5*	·140 *3,5*	·135 *3,4*
2·75 *70,0*	3·0 *76,0*	·150 *3,8*	·150 *3,8*	·145 *3,7*
3·0 *76,0*	3·25 *82,0*	·160 *4,0*	·160 *4,0*	·155 *3,9*

Tolerances on declared values:—

P.C.P.	5%+·010 in. (0,25 mm.)
P.V.C. Up to and including ·075 in. (1,9 mm.)	5%+·007 in. (0,18 mm.)
Above ·075 in. (1,9 mm.)	5%+·010 in. (0,25 mm.)
Lead Alloy	5%+·005 in. (0,13 mm.)

For lead-alloy sheath, if the minimum at a point method of measurement is preferred the thickness of sheath is to be at least the values given above reduced by ·010 in. (0,25 mm.)

The voltage drop from the main switchboard busbars to any point in the installation when the cables are carrying maximum current under normal conditions of service, is not to exceed 6 per cent of the nominal voltage.

In assessing the current rating of lighting circuits every lampholder is to be assessed at the maximum load likely to be connected to it, with a minimum of 60 watts, unless the fitting is so constructed as to take only a lamp rated at less than 60 watts.

Cables supplying cargo winches, cranes, windlasses and capstans are to be suitably rated for their duty. Unless the duty is such as to require a longer time rating cables for winch or crane motors may be half hour rated on the basis of the half hour b.h.p. of the motors. Cables for windlass and capstan motors are to be not less than one hour rated on the basis of the one hour b.h.p. of the motor. In all cases the rating is to be subject to the voltage drop being within the specified limits.

The following Table 8.4 gives the maximum permissible continuous-current rating for single- and multi-core cables, except that where a more precise evaluation of current rating has been carried out based on experimental or calculated data details may be submitted for approval.

CURRENT RATING IN AMPERES

(Based on ambient temperature 45° C.)

TABLE 8.4 (a)—GENERAL PURPOSE RUBBER AND P.V.C.

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		9	7	6
		1	9	7	6
3/·029	·002		11	9	7
		1,5	12	10	8
3/·036; 1/·064	·003		14	11	9
		2,5	17	14	11
7/·029	·0045		18	16	13
		4	23	19	16
7/·036	·007		25	21	17
		6	30	25	21
7/·044	·01		31	26	22
7/·052	·0145		37	31	26
		10	41	34	28
7/·064	·0225		51	43	35
		16	54	45	37
19/·044	·03		60	51	42
		25	70	59	49
19/·052	·04		72	61	50
		35	86	73	60
19/·064	·06		92	78	64
		50	105	91	75
		60	120	100	84
19/·083	·1		125	105	87
		70	130	110	91
		95	160	135	110
37/·072	·15		160	135	110
		120	180	155	130
37/·083	·2		190	160	135
		150	210	180	145
37/·093	·25		220	185	155
		185	240	205	170
37/·103	·3		250	210	175
		240	280	240	200
61/·093	·4		300	255	210
		300	325	275	225
61/·103	·5		D.C. 340 A.C.	D.C. 290 A.C.	D.C. 240 A.C.
	·6		380 375	325 320	265 265
		400	390 385	330 325	275 270
91/·103	·75		445 420	375 360	310 295
		500	450 430	380 365	315 300
		625	520 470	440 375	360 330
127/·103	1·0		530 480	450 405	370 335

TABLE 8.4 (b)—HEAT RESISTING RUBBER

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015	1	14	11	9
			14	11	9
3/·029	·002		17	14	11
3/·036; 1/·064	·003	1,5	19	16	13
			21	17	14
		2,5	25	21	17
7/·029	·0045	4	27	23	18
			32	27	22
7/·036	·007		35	29	24
7/·044	·01	6	42	35	29
			44	37	30
7/·052	·0145		55	46	38
7/·064	·0225	10	58	49	40
			74	62	51
		16	78	66	54
19/·044	·03	25	87	74	61
			100	86	71
19/·052	·04		105	89	73
19/·064	·06	35	125	105	88
			135	115	94
		50	155	135	110
19/·083	·1	60	175	150	125
			185	155	130
		70	195	165	135
37/·072	·15	95	235	200	160
			235	200	165
		120	270	230	190
37/·083	·2	150	285	240	200
			310	265	215
37/·093	·25		325	275	225
37/·103	·3	185	355	300	250
			365	310	255
		240	415	355	290
61/·093	·4	300	435	370	305
			480	410	335
61/·103	·5		D.C. 500 A.C.	D.C. 425 A.C.	D.C. 350 A.C.
	·6	400	560 550	475 465	390 385
			570 560	485 475	400 390
91/·103	·75		640 610	540 520	450 425
		500	650 620	550 530	455 435
		625	740 670	630 570	520 470
127/·103	1·0		760 690	650 580	530 480

TABLE 8.4 (c)—VARNISHED CAMBRIC, BUTYL

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		15	12	10
		1	15	12	10
3/·029	·002		19	16	13
		1,5	21	17	14
3/·036; 1/·064	·003		23	19	16
		2,5	27	22	18
7/·029	·0045		29	24	20
		4	35	29	24
7/·036	·007		38	32	26
		6	45	38	31
7/·044	·01		48	40	33
7/·052	·0145		60	51	42
		10	63	53	44
7/·064	·0225		78	66	54
		16	83	70	58
19/·044	·03		93	79	65
		25	110	93	77
19/·052	·04		115	96	79
		35	135	115	94
19/·064	·06		145	120	100
		50	170	145	115
		60	185	160	130
19/·083	·1		195	165	135
		70	205	175	145
		95	250	215	175
37/·072	·15		255	215	180
		120	290	245	205
37/·083	·2		300	255	210
		150	335	285	235
37/·093	·25		345	295	240
		185	380	320	265
37/·103	·3		390	330	270
		240	445	380	310
61/·093	·4		465	395	325
		300	510	435	355
61/·103	·5		D.C. 530 A.C.	D.C. 450 A.C.	D.C. 370 A.C.
	·6		600 585	510 495	420 410
		400	610 590	520 500	425 415
91/·103	·75		680 640	580 540	475 450
		500	690 640	590 550	485 450
		625	790 680	680 580	550 480
127/·103	1·0		810 690	690 590	570 485

TABLE 8.4 (d) ASBESTOS-VARNISHED CAMBRIC

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		16	13	11
		1	16	13	11
3/·029	·002		20	17	14
		1,5	22	18	15
3/·036; 1/·064	·003		25	21	17
		2,5	28	23	19
7/·029	·0045		31	26	22
		4	37	31	25
7/·036	·007		41	34	28
		6	48	40	33
7/·044	·01		51	43	35
7/·052	·0145		64	54	44
		10	67	57	47
7/·064	·0225		83	70	58
		16	89	75	62
19/·044	·03		99	84	69
		25	115	99	82
19/·052	·04		120	105	94
		35	145	120	100
19/·064	·06		155	130	110
		50	180	155	125
		60	200	170	140
19/·083	·1		210	180	145
		70	220	185	155
		95	270	220	190
37/·072	·15		270	230	190
		120	310	265	215
37/·083	·2		320	270	225
		150	355	305	250
37/·093	·25		370	315	260
		185	405	345	285
37/·103	·3		415	355	290
		240	475	405	330
61/·093	·4		495	425	350
		300	540	465	380
61/·103	·5		D.C. 570 A.C.	D.C. 480 A.C.	D.C. 400 A.C.
	·6		640 620	545 530	450 435
		400	650 630	550 540	455 440
91/·103	·75		730 680	620 580	510 475
		500	740 690	630 590	520 480
		625	850 730	720 620	590 510
127/·103	1·0		870 740	740 630	610 520

TABLE 8.4 (e) SILICONE RUBBER, MINERAL

Nominal cross section			Single core	2 core	3 or 4 core
	sq. in.	sq. mm.			
1/·044	·0015		19	16	13
		1	20	17	14
3/·029	·002		23	19	16
		1,5	25	21	17
3/·036; 1/·064	·003		27	23	18
		2,5	31	26	21
7/·029	·0045		34	29	23
		4	41	35	28
7/·036	·007		44	37	30
		6	53	45	37
7/·044	·01		56	47	39
7/·052	·0145		70	59	49
		10	73	62	51
7/·064	·0225		93	79	65
		16	99	84	69
19/·044	·03		110	93	77
		25	130	110	92
19/·052	·04		135	115	94
		35	165	140	115
19/·064	·06		175	150	125
		50	205	175	145
		60	230	195	160
19/·083	·1		240	205	170
		70	255	215	175
		95	310	265	215
37/·072	·15		315	265	220
		120	360	305	250
37/·083	·2		380	325	265
		150	420	355	290
37/·093	·25		440	375	310
		185	485	410	340
37/·103	·3		500	425	350
		240	570	485	400
61/·093	·4		600	510	420
		300	660	560	460
61/·103	·5		690	590	485

Correction Factors for Current Rating

814 (*a*) BUNCHING OF CABLES—Where more than six cables belonging to the same circuit are bunched together a correction factor of 0·85 is to be applied.

(*b*) AMBIENT TEMPERATURE—When it is known that the ambient temperature is different from that given in M 106 the following correction factors are to be applied.

TABLE 8.5

Insulation	Correction Factor for Ambient Temperature			
	40°C. (104°F.)	45°C. (113°F.)	50°C. (122°F.)	55°C. (131°F.)
Rubber or P.V.C. (general purpose)	1·15	1·00	0·82	—
Rubber (heat-resisting quality)	1·08	1·00	0·91	0·82
Varnished Cambric ...	1·07	1·00	0·93	0·85
Asbestos-Varnished Cambric	1·06	1·00	0·94	0·87
Mineral, Silicone Rubber...	1·05	1·00	0·95	0·89

(*c*) INTERMITTENT SERVICE—Where the load is intermittent the correction factors in Table 8.6 may be applied for half hour and one hour ratings. In no case is a shorter rating than one half hour rating to be used, whatever the degree of intermittency.

Installation of Cables

815 Cable runs are to be, as far as possible, straight and accessible.

816 The installation of cables across expansion joints in the ship's structure is to be avoided. Where this is not practicable a loop of cable of length proportional to the expansion of the joint is to be provided. The internal radius of the loop is to be at least 12 times the external diameter of the cable.

817 Where a duplicate supply is required the two cables are to follow different routes which are to be as far apart as practicable.

818 Cables having insulating materials with different maximum-rated conductor temperatures are not to be bunched together, or, where this is not practicable, the cables are to be operated so that no cable

TABLE 8.6

Correction Factor	Half Hour Rating		One Hour Rating	
	With Metallic Sheath	Without Metallic Sheath	With Metallic Sheath	Without Metallic Sheath
1·0	Up to ·03 sq. in. 20 sq. mm.	Up to ·1 sq. in. 75 sq. mm.	Up to ·1 sq. in. 67 sq. mm.	Up to ·3 sq. in. 230 sq. mm.
1·1	·04–·06 sq. in. 21–40 sq. mm.	·15 sq. in. 76–125 sq. mm.	·15–·25 sq. in. 68–170 sq. mm.	·4–·6 sq. in. 231–400 sq. mm.
1·15	·1 sq. in. 41–65 sq. mm.	·2–·25 sq. in. 126–180 sq. mm.	·3–·4 sq. in. 171–290 sq. mm.	·75–1·0 sq. in. 401–600 sq. mm.
1·2	66–95 sq. mm.	·3 sq. in. 181–250 sq. mm.	·5–·6 sq. in. 291–430 sq. mm.	
1·25	·15–·2 sq. in. 96–130 sq. mm.	·4 sq. in. 251–320 sq. mm.	·75–1·0 sq. in. 431–600 sq. mm.	
1·3	·25 sq. in. 131–170 sq. mm.	·5–·6 sq. in. 321–400 sq. mm.		
1·35	·3 sq. in. 171–220 sq. mm.	·75 sq. in. 401–500 sq. mm.		
1·4	·4 sq. in. 221–270 sq. mm.			

reaches a temperature higher than that permitted for the lowest temperature-rated cable in the group.

819 Cables having a protective covering which may damage the covering of other cables are not to be bunched with those other cables.

820 When installing cables the minimum internal radius of bend is to be generally in accordance with :—

6 d for rubber and PVC cables with metal covering
6 d for rubber and PVC cables exceeding 1 in. (25,4 mm.) diameter and without metal covering
4 d for rubber and PVC cables exceeding ·375 in. (9,5 mm.) diameter and without metal covering
8 d for varnished cambric cables
4 d for mineral-insulated cables

(d=overall diameter of cable)

Mechanical Protection

821 Cables exposed to risk of mechanical damage are to be protected by metal channels or casing or enclosed in steel conduit unless the protective covering (e.g., armour or sheath) is sufficient to withstand the possible damage.

822 Cables in cargo holds and other spaces where there is exceptional risk of mechanical damage are to be suitably protected, even if armoured, unless the steel structure affords adequate protection. (*See also* M 1616.)

823 Metal casings for mechanical protection of cables are to be efficiently protected against corrosion.

Earthing

824 Metal coverings of cables are to be effectively earthed at both ends of the cable, except in final sub-circuits where earthing at the supply end only will be considered adequate.

825 The electrical continuity of all metal coverings of cables throughout the length of the cable, particularly at joints and tappings is to be ensured.

826 The lead sheath of lead-sheathed cables is not to be used as the sole means of earthing the non-current carrying parts of items of equipment.

Securing of Cables

827 Cables are to be effectively supported and secured without their coverings being damaged.

828 The distances between supports is to be chosen according to the type of cable, the distances being generally in accordance with Table 8.7 below.

829 Supports and accessories are to be robust and are to be of corrosion-resistant material or suitably corrosion inhibited before erection.

Penetration of Bulkheads and Decks

830 Penetration of watertight bulkheads or decks is to be carried out with either individual watertight glands or with packed watertight boxes carrying several cables. However carried out the watertight integrity of the bulkheads or deck is to be maintained. (*See also* 810.)

831 Cables passing through decks are to be protected by deck tubes or ducts.

832 Where cables pass through non-watertight bulkheads or structural steel the holes are to be bushed with lead or other approved material. If the steel is ·25 in. (6 mm.) thick, adequately rounded edges may be accepted as the equivalent of bushing.

833 Materials used for glands and bushings are to be such that there is no risk of corrosion.

TABLE 8.7

External diameter of Cable		Non-Armoured Cables	Armoured Cables
Exceeding	Not Exceeding		
	0·3 in. (7,6 mm.)	8 in. (20 cm.)	10 in. (25 cm.)
0·3 in. (7,6 mm.)	0·5 in. (12,7 mm.)	10 in. (25 cm.)	12 in. (30 cm.)
0·5 in. (12,7 mm.)	0·75 in. (20 mm.)	12 in. (30 cm.)	14 in. (35 cm.)
0·75 in. (20 mm.)	1·25 in. (30 mm.)	14 in. (35 cm.)	16 in. (40 cm.)
1·25 in. (30 mm.)		16 in. (40 cm.)	18 in. (45 cm.)

834 Where rectangular holes are cut in bulkheads or structural steel the corners are to be radiused.

Installation in Pipes and Conduits

If installed in pipe or conduit the following rules are to be complied with.

835 Metal conduit systems are to be earthed and are to be mechanically and electrically continuous across joints. Individual short lengths of conduit need not be earthed.

836 The internal radius of bend of pipes and conduit is to be not less than that laid down for cables provided that for pipes exceeding 2·5 in. (64 mm.) diameter the internal radius of bend is not less than twice the diameter of the pipe.

837 The drawing-in factor (ratio of the sum of the cross sectional areas of the cables to the internal cross sectional area of the pipe) is not to exceed 0·4.

838 Expansion joints are to be provided where necessary.

839 Where necessary, ventilation openings are to be provided at the highest and lowest points so as to permit air circulation and to prevent accumulation of water.

Where cables are laid in trunks the trunks are to be so constructed as not to afford passage for fire from one between deck or compartment to another.

840 High voltage cables, e.g., those used for cold cathode luminous discharge lamps, are not to be installed in metal conduit unless protected by metal sheath or screen.

841 Non-metallic ducting or conduit is to be of flame-retardant material. PVC conduit is not to be used in refrigerated spaces or on open decks, unless specially approved.

Installation in Refrigerated Spaces

842 Cables installed in refrigerated spaces are to have a watertight or impervious sheath and are to be protected against mechanical damage. If an armoured cable is used the armour, unless galvanized, is to be protected against corrosion by a further moisture-resisting covering.

Cables entering a refrigerated space are to pass directly through the walls or lagging and are to be protected by a tube sealed at each end. Alternatively, the cables may be passed through solid door frames the necessary holes being sealed at each end.

Cables installed in a refrigerated space are not to be embedded in the walls or lagging.

Precautions are to be taken to prevent the placing of hooks round the cable as a casual means of suspension.

PVC insulated cables are not to be used in refrigerated spaces.

Cables for Alternating Current

843 Where it is necessary to use single-core cables for alternating-current circuits rated in excess of 20 A the following rules are to be complied with :—

(*a*) Cables are to be either non-armoured or armoured with non-magnetic material.

(*b*) If installed in pipe or conduit, cables belonging to the same circuit are to be installed in the same conduit, unless the conduit or pipe is of non-magnetic material.

(*c*) Cable clips are to include cables of all phases of a circuit unless the clips are of non-magnetic material.

(*d*) When installing two, three or four single-core cables forming respectively single-phase circuits, three-phase circuits or three-phase and neutral circuits the cables are to be in contact with one another, as far as possible. In any event the distance between adjacent cables is not to be greater than 1 diameter.

(*e*) If single-core cables, of current rating greater than 250 A are run along a steel bulkhead wherever practicable the cables should be spaced away from the steel.

(*f*) Magnetic material is not to be placed between single-core cables of a group. Where cables pass through steel plates all cables of the same circuit are to pass through a plate or gland so constructed that there is no magnetic material between the cables and the clearance between the cables and magnetic material is not less than 3 in. (75 mm.) wherever practicable.

Cable Ends

844 The ends of all conductors of cross-sectional area greater than 0·0065 sq. in. (4 sq. mm.) are to be fitted with soldering sockets, compression type sockets or mechanical clamps. Corrosive fluxes are not to be used.

Cables having a hygroscopic insulation (e.g., varnished cambric or mineral insulated) are to have their ends sealed against ingress of moisture.

Cables with a supplementary insulating belt beneath the protective sheath are to have additional insulation at those points where the insulation of each core makes or may make contact with earthed metal.

Joints and Branch Circuits

845 If a joint is necessary it is to be carried out so that all conductors are adequately secured, insulated and protected from atmospheric action. Terminals or busbars are to be of dimensions adequate for the cable rating.

Testing

846 The following tests are to be made at the manufacturers' works prior to despatch and may be required to be carried out under the supervision of the Surveyors.

All main cable for electric propelling machinery is to be tested in the presence of the Surveyors. (*See* M 1701.)

High Voltage Test

847 The test is to be carried out on finished cables with either direct-current or single-phase alternating-current at the manufacturers' discretion. The power available in the test equipment is to be sufficient to maintain in the cable the specified test voltage and the charging current. The voltage is to be applied gradually so as to arrive at the specified figure in approximately one minute. The test voltage is to be applied as follows:—

For cables with metallic covering the test voltage is to be applied between conductor(s) and the metallic covering. For cables with non-metallic impervious sheath the voltage is to be applied between conductor(s) and the water in which the cable is to be immersed for at least one hour before the test. For cables having a non-metallic covering which might be impaired if immersed in water, the voltage is to be applied to samples, at least 40 in. (1 m.) long, the surface being covered with metal foil. In addition, for multi-core cables the voltage is to be applied in turn between each conductor and all other conductors connected together.

The test voltage in all cases is to be applied for 5 min., without failure, the value being in accordance with:—

TABLE 8.8

Rated Voltage of Cable		Test Voltage	
Above	Up to and including	A.C. Volts	D.C. Volts
	250	1500	3000
250	750	2500	5000
750	1100	3000	6000
1100	3300	10000	20000
3300	6600	16000	32000

NOTE.—For mineral insulated cables having a rated voltage up to and including 440 V the test voltage is to be 2000 V alternating current and for voltages above 440 V the test voltage is to be 3000 V alternating current.

Insulation Resistance

848 Immediately after the high voltage test the insulation resistance is to be measured and recorded, using a direct-current voltage of at least 400 V and the measurement being made after electrification for 1 minute. (*See also* M 1902.)

Spark Testing

849 Spark testing may be accepted as an alternative to the high voltage and insulation resistance test for cables with rubber or rubber-like insulation. The test is to be made at the core stage except for single core braided and compounded cables which may be tested at the finished stage.

The core or cable is to withstand the test voltage without failure and the speed at which the cable passes through the electrode is to be such that every point is in contact with the electrode for not less than 0·1 sec. Test voltages are given in Table 8.9.

TABLE 8.9

Rated Voltage of Cable V	Conductor Sectional Area		Test Voltage (r.m.s.) kV
	Above.	Up to and including	
250	—	·0225 sq. in. (16 sq. mm.)	6
	·0225 sq. in. (16 sq. mm.)	·04 sq. in. (25 sq. mm).	8
	·04 sq. in. (25 sq. mm.)		10
660	—	·04 sq. in. (25 sq. mm.)	10
	·04 sq. in. (25 sq. mm.)		12

Flame-Extending, Flame-Retardant and Fire-Resisting Cables

850 A sample of cable 48 in. (1,2 m.) long is to be clamped vertically in a three-sided enclosure with open top, of size suitable to contain the cable. A bunsen burner of nominal bore $\frac{3}{8}$ in. (10 mm.) fed with ordinary illuminating gas at normal pressure, giving a flame approximately 5 in. (125 mm.) long with an inner blue cone approximately 1·5 in. (40 mm.) long, is to be applied to the cable so that the tip of the blue cone touches the cable at approximately 12 in. (0,4 m.) from its lower end. The burner is to be held at 45° to the vertical and the flame applied for a time

$$t \text{ (secs)} = 10 + \frac{W}{50}$$

where W = weight of cable sample in grams.
The application is not to be continuous but in steps of 10 seconds, with 10 seconds interruption between applications.

At the end of this period the burner is to be removed and cables are to be graded as follows:—

(*a*) Flame extending when the flame travels along the whole length of the specimen.

(*b*) Flame retardant when the flame extinguishes before reaching the top of the specimen.

(*c*) Fire resisting when, in addition to (b) the specimen is able to withstand after cooling an alternating-current test voltage of twice its rated voltage for 1 minute.

NOTE.—To ensure correct heat in the gas flame a bare copper wire 0·028 in. (0·7 mm.) diameter and of length 4 in. (100 mm.) is to be inserted horizontally in the flame and 2 in. (50 mm.) above the top of the burner, so that the free end of the wire is vertically above the edge of the burner on the side of the burner remote from the supported end of the wire. If the wire takes more than 6 seconds to melt then the flame is not hot enough for the test.

Other tests which are the equivalent of the above may be submitted for consideration.

Quality of Materials

851 The quality of materials is to be in accordance with the recommendations of I.E.C. Publication 92.

Alternative requirements of National Standards will be considered.

Section 9

TRANSFORMERS

901 The following Rules apply to all transformers for general use rated from 1 kVA to 1,000 kVA inclusive and suitable for operating over an input voltage range up to 3,300 volts line to line.

Transformers outside these limits will be specially considered.

Construction

902 Transformers except those for motor starting are to be double wound.

Liquid Cooled Transformers

903 Proposals for the use of liquid cooled transformers will be specially considered.

Number and Rating of Transformers

904 Where essential services are supplied the number and ratings of transformers are to be sufficient to ensure the operation of essential services even when one transformer is out of service.

Regulation

905 The inherent regulation at 0·8 power factor is not to exceed 5 per cent.

Regulation of the complete system is to comply with M 813.

Temperature Rise

906 The temperature rise of windings of dry type transformers above the ambient temperatures given in M 106, when measured by resistance, during continuous operation at the maximum rating is not to exceed:—

Class A 50° C.
Class B 70° C.

Proposals to use Class H or Class C insulation will be specially considered.

Short Circuit

907 All transformers are to be capable of withstanding, without damage, the thermal and mechanical effects of a short-circuit at the terminals of any winding for 2 secs.

Tests

908 The following tests are to be carried out on all transformers at the manufacturers' works, and a certificate of tests issued by the manufacturer.

HIGH VOLTAGE TEST

(*a*) The voltage is to be applied to each winding in turn, between the winding under test and the remaining windings, core, frame and tank or casing connected together and to earth.

The test is to be made with 1 kV a.c. plus twice the highest voltage between lines with a minimum of

2·5 kV at any frequency between 25 c/s and 100 c/s and maintained for 1 minute without failure.

INDUCED HIGH VOLTAGE TEST

(*b*) To test between turns, coils and terminals an a.c. voltage is to be applied between the above parts corresponding to twice the voltage appearing between these parts when rated voltage is applied to the terminals. The duration of the test is to be 1 minute for any test frequency up to and including twice the rated frequency.

INSULATION RESISTANCE

(*c*) The insulation resistance of each winding in turn to all the other windings, core, frame and tank or casing connected together and to earth is to be measured and recorded together with the temperature of the transformer at the time of the test.

TEMPERATURE RISE

(*d*) One transformer of each size and type is to be given a temperature rise test.

Section 10

LIGHTING

1001 Lighting which is essential for the safety and the working of the ship is to comply with the following Rules :—

The voltage of tungsten filament lampholders is not to exceed :—

BAYONET FITTING		
Normal	B 22	250 V
Small (single contact)	B 15s	130 V
Small (double contact)	B 15d	130 V
SCREW FITTING		
Goliath	E 40	250 V
Medium	E 27	250 V
Small	E 14	250 V
Miniature	E 10	24 V

Lamps are to be in accordance with the following :—

B 22 up to 200 W
E 27 up to 200 W
E 40 no limit

Lampholders are to be constructed of flame-retarding and non-hygroscopic material. All metal parts are to be of robust construction. Goliath lampholders are to be provided with means for locking the lamp in the holder. The temperature of cable connections is not to exceed the maximum conductor temperature permitted for the cable given in M 802.

Fluorescent Lighting

1002 Fittings, reactors, capacitors and other auxiliaries are not to be mounted on surfaces which are subject to high temperatures. In ships for unrestricted service they are to be capable of operating at the ambient temperatures given in M 106.

Capacitors of 0·5 microfarads and above are to be provided with a means of prompt discharge on disconnection of the supply.

Inductors and high reactance transformers are to be installed as close as practicable to the associated discharge lamp.

1003 Where cold cathode luminous discharge lamps of normal operating voltage above 250 V are used a warning notice calling attention to the voltage is to be displayed at points of access to the lamps and where otherwise necessary.

Section 11

ACCESSORIES

Enclosures

1101 Enclosures are to be of metal or of flame-retardant insulating material.

Inspection and Draw Boxes

1102 If metal conduit systems are used inspection and draw boxes are to be of metal and are to be in rigid electrical and mechanical connection with the conduits.

Socket Outlets and Plugs

1103 Where it is necessary to earth the non-current-carrying parts of portable or transportable equipment an effective means of earthing is to be provided at the socket outlet.

On weather decks, galleys, laundries, machinery spaces and all wet situations, socket outlets and plugs are to be effectively shielded against rain or spray and are to be provided with means of maintaining this quality after removal of the plug.

The temperature rise on the live parts of socket outlets and plugs is not to exceed 30° C. Socket outlets and plugs are to be so constructed that they cannot be readily short circuited whether the plug is in or out, and so that a pin of the plug cannot be made to earth either pole of the socket outlet.

All socket outlets of current rating 15 A or more are to be provided with a switch.

Section 12

HEATING AND COOKING EQUIPMENT

1201 Heaters are to be so constructed, installed and protected that clothing, bedding and other inflammable material cannot come in contact with them in such a manner as to cause risk of fire. There is to be no excessive heating of adjacent bulkheads or decks.

Section 13

BATTERIES

The following Rules apply to permanently installed secondary batteries.

Construction

1301 The cells of all batteries are to be so constructed and secured as to prevent spilling of the electrolyte due to the motion of the ship and to prevent emission of acid or alkaline spray.

Location

1302 Alkaline batteries and lead acid batteries are not to be installed in the same compartment.

Large batteries are to be installed in a space assigned to the batteries only or alternatively in a deck box if such a space is not available.

Engine starter batteries are to be located as close as practicable to the engine(s) served. If such batteries cannot be accommodated in the battery room they are to be installed so that adequate ventilation is ensured.

Lining of Compartments

1303 Where acid is used as the electrolyte a tray of lead, or wood lined with lead is to be provided below the cells. Alternatively, the deck below the cells is to be protected with lead or other acid-resisting material so as effectually to prevent any acid from lodging in contact with the ship's structure.

The interiors of all battery compartments including shelves are to be painted with corrosion-resistant paint.

Equipment

1304 Switches, fuses and other electrical equipment liable to cause an arc are not to be fitted in battery compartments.

Supports

1305 Batteries are to be so arranged that each cell or crate of cells is accessible from the top and at least one side. Cells or crates are to be carried on non-absorbent insulating supports. Similar insulators are to be fitted to prevent any movement of cells arising from the motion of the ship.

Ventilation

1306 Battery compartments are to be ventilated by an independent ventilating system.

Natural ventilation may be employed if ducts can be run directly from the top of the compartment to the open air with no part of the duct more than 45° from the vertical. If natural ventilation is impracticable mechanical ventilation is to be provided. Interior surfaces of ducts and fans are to be painted with corrosion-resistant paint. Fan motors are not to be located in the air stream.

All openings through the battery compartment bulkheads or decks, other than ventilation openings are to be effectively sealed to reduce the possibility of escape of gas from the battery compartment, into the ship.

Where practicable, battery lockers are to be ventilated similarly to battery compartments.

Deck boxes are to be adequately ventilated and means provided to prevent ingress of water.

Size of Batteries and Charging Facilities

1307 Where batteries are used for starting main engines at least two batteries are to be fitted of such combined size that H 711 is complied with.

Adequate charging facilities are to be provided and where batteries are charged from line voltage, by means of a series resistor, protection against reversal of current is to be provided when the charging voltage is 20 per cent of line voltage or higher.

In d.c. systems means are to be provided to isolate the batteries from the low voltage system when being charged from a higher voltage system.

Protection

1308 Batteries, except starter batteries, are to be protected against short circuit by a fuse in each insulated conductor or a multi-pole circuit-breaker at a position adjacent to the battery compartment.

1309 A permanent notice is to be fitted to all battery compartments prohibiting naked lights and smoking.

Section 14

INTERNAL COMMUNICATIONS

1401 Where a communication circuit takes its supply direct from power or lighting circuits and in other cases where the voltage of supply exceeds 50 V a.c. or 60 V d.c. all equipment is to be in accordance with the Rules for power and lighting circuits.

1402 Cables are to be fitted in a similar manner to cables installed for lighting and power, but are to be segregated from the latter unless either the lighting and power cables or the communication cables are metal sheathed, or non-metallic impervious sheathed.

1403 Communication circuits other than those supplied from primary batteries are to be protected against overload and short circuit.

Passenger Alarms

1404 In all passenger ships, except those engaged on short international voyages, electrically operated alarms, for summoning passengers to muster stations are to be fitted. They are to be operable from the bridge.

Section 15

SEMI-CONDUCTOR RECTIFIERS FOR POWER

1501 Rectifier stacks are to be so arranged that they may be removed from equipment without dismantling the complete unit.

1502 Where forced cooling is provided the apparatus is to be so arranged that the rectifier cannot remain loaded unless effective cooling is maintained.

1503 When necessary, means are to be provided to guard against d.c. voltage rise due to regenerated power.

1504 When operated in parallel with other sources of d.c. power load sharing is to be such that under normal conditions overloading of any unit does not occur and the combination of paralleled equipment is stable.

1505 Fungus protection of the mercury type is not to be used in the vicinity of selenium rectifiers.

1506 Monocrystalline rectifiers such as germanium and silicon are to be capable of withstanding the effects of transient over-voltages coming from the ship's network.

Section 16

SPECIAL REQUIREMENTS FOR OIL TANKERS AND SHIPS INTENDED FOR THE CARRIAGE IN BULK OF LIQUID CARGOES HAVING A FLASH POINT OF 150° F. (65·5° C.) OR LESS

Generation and Distribution

1601 The following generation and distribution systems only are to be used :—

Two-wire insulated for d.c. and single-phase a.c.

Three-wire insulated for three-phase a.c.

1602 No current-carrying part of the distribution system is to be earthed other than through an earth indicating device or capacitors used for radio interference suppression.

Equipment in Dangerous Spaces

1603 No electrical equipment or wiring, other than that certified intrinsically safe in respect of the gases and vapours involved (*see* M 109) is to be installed in any space where inflammable or explosive vapour may normally be expected to accumulate such as :—

Cargo oil tanks.

Cofferdams adjoining cargo oil tanks.

Cargo pump rooms.

Enclosed spaces immediately above cargo tank crowns (e.g., between decks).

Enclosed spaces, other than cofferdams, adjacent to, and below, the top of a cargo oil tank.

On open deck within 10 ft. (3 m.) of any oil tank outlet or vapour outlet.

except as detailed in 1604 to 1609.

1604 In enclosed spaces immediately above cargo tank crowns lighting fittings only are to be installed and they are to be of flameproof type. The switches controlling such fittings are to be double-pole and are to be located in a safe place.

1605 Electrical equipment additional to the lighting fittings referred to in 1604 above may be installed in between deck spaces immediately above cargo tank crowns provided that :—

(*a*) Such equipment is housed in a suitably ventilated compartment having access solely from the deck above, and of which the floor is separated from the cargo oil tanks by a cofferdam, and the boundaries are gas tight with respect to the cofferdam and the between deck space.

(*b*) Cables are supported clear of the gas tight boundaries of the compartment. Plans showing the construction of the compartment, the electrical apparatus to be housed therein and the provisions for ventilation are to be submitted.

1606 In positions on open deck and within a distance of 10 ft. (3 m.) from cargo tank hatches, sight ports, tank cleaning openings, ullage openings, sounding pipes, cargo vapour outlets or ventilators, or cargo pump room entrances electrical equipment is to be flameproof.

1607 Hull fittings containing the oscillators of electric sounding devices may be installed in a cofferdam or cargo pump room forward of the oil tanks provided that :—

(*a*) Such fittings are housed in a gas tight enclosure clear of the cargo tank bulkhead.

(*b*) The cables to the oscillators are run within the space in heavy gauge galvanized steel pipe with bolted flange joints and led through watertight glands fitted at the external extremity of the pipe.

1608 Cargo pump rooms may be lit by one or both of the following methods :—

(*a*) By flameproof fittings within the compartment. The lamps are to be arranged on at least two independent circuits controlled by fuses and double-pole switches located in a safe space outside the compartment. The lamps and corresponding switches and fuses are to be suitably labelled for identification purposes. Well glasses and other covers are to be secured by screws or nuts requiring a special key for their removal. The cables are to be either lead sheathed and armoured or mineral-insulated metal-sheathed protected from mechanical damage and supported clear of bulkheads and deckheads.

(*b*) By fittings located in a safe space. Where a safe space is immediately adjacent the cargo pump rooms may be lighted either :—

(i) From that safe space through gas tight and watertight glazed ports permanently fitted in the bulkhead or deckhead.

(ii) Or by lighting fittings which are flameproof relative to the cargo pump room and gas tight relative to the safe space and so designed to admit replacement of the lamp from the safe space.

1609 Enclosed spaces other than cofferdams adjacent to and below the top of a cargo tank may be lighted in the same manner as cargo pump rooms.

Portable Lamps

1610 Portable lamps other than self-contained battery fed or equivalent lamps of a certified type, in respect of the gases and vapours involved, are not to be used in any dangerous space.

Section and Distribution Boards

1611 The enclosing cases of all section boards and distribution fuse boards are to be of metal and of robust construction.

Lighting Fittings

1612 Except in accommodation spaces enclosing cases of lighting fittings are to be of metal or equally durable and non-inflammable approved material.

Switchboards

1613 Every outgoing circuit, rated at 15 A and above, from the main switchboard and/or section boards is to be provided with a multi-pole (linked) circuit-breaker or a multi-pole (linked) switch arranged to interrupt all poles simultaneously with fuses in each pole.

Fuses

1614 Only cartridge-type fuses are to be used.

Earth Indicating Devices

1615 Every earth indicating device, other than one depending solely on lamps, is to be such that the flow of current to earth cannot exceed 30 mA and the inductance of the path to earth in the indicating circuit is not to exceed 60 mH. Where an earth indicating system using lamps is used, such lamps are to be of the metal filament type, each not exceeding 15 watts. The system employing a single lamp is not to be used.

Cables on Decks and Fore and Aft Gangways

1616 Cables on fore and aft gangways and in dangerous spaces, where permitted, are to be either :—

Lead-alloy sheathed and armoured, with or without braiding, or

Lead-alloy sheathed and metal braided, or

Mineral-insulated copper sheathed, or

Non-metallic impervious sheathed and wire braided, provided laid in pipe, except that equivalent arrangements may be accepted on fore and aft gangways.

Aluminium wire braid is not to be used.

1617 Cables installed on deck in way of cargo tanks or on fore and aft gangways are to be protected against mechanical damage. Where pipes are used the total cross-sectional area of the cables contained within a pipe is not to be more than 30 per cent of the internal cross-sectional area of the pipe. Glands are to be fitted at each bulkhead through which the pipes pass, to allow for expansion and the working of the ship. The pipe system is to be drained and ventilated.

1618 All cables except mineral-insulated copper sheathed cables installed on deck in way of cargo tanks, or on fore and aft gangways and all pipes containing such cables are to be kept throughout their length at such distance from steam and exhaust pipes as to be substantially free from any heating effect from such pipes. At the bulkhead this distance is to be not less than 18 in. from the flanges of steam pipes more than 3 in. in diameter, and not less than 12 in. from the flanges of steam pipes 3 in. or less in diameter.

Flameproof Equipment

1619 Where flameproof equipment is required, effective means of complete isolation located in a safe space is to be provided. Effective provision is to be made to prevent unauthorised operation resulting in restoration of supply while the risk of exposing live conductors exists.

Intrinsically Safe Equipment

1620 Where intrinsically safe equipment is installed the wiring of the circuit is to be physically separated from that of other circuits. Intrinsically safe equipment may be used where flameproof equipment is required by the Rules.

Section 17

ELECTRIC PROPELLING MACHINERY

General

1701 All electric propelling machinery including switchgear, control gear, cables, main and auxiliary generators, motors and exciters is to comply with the relevant sections of the Rules and is to be constructed under special survey.

1702 Prime movers are to comply with the relevant sections of Chapter H.

1703 Armature shafts and other important steel forgings and castings are to comply with the requirements of Chapter P.

1704 The torsional vibration characteristics of the propulsion system are to be submitted as required by H 301 or H 601 whichever is applicable.

1705 Cooling water and lubricating oil systems are to comply with E 8 and E 9 where applicable.

General Arrangements

1706 Where the arrangements permit a propulsion motor to be connected to generating plant having a continuous rating greater than the motor rating, means are to be provided to limit the continuous input to the motor to a value not exceeding the continuous full load torque for which the motor and shafts are approved.

1707 Motors of 500 h.p. or over and generators of 400 kW or over are to be provided with means for heating the windings to prevent condensation when idle. If steam pipes are used for this purpose the joints are not to be within the machine.

Excitation

1708 Systems dependent on the auxiliary generators for excitation are to be capable of manœuvring and of maintaining power at all times with a fall of 10 per cent excitation voltage at the busbars.

Where motor driven exciters, boosters, balancers or rectifiers are provided for excitation purposes, provision for an alternative supply of excitation is to be made. Where two machines are used each of at least 50 per cent of the required power it will be sufficient to provide one spare machine.

1709 Negative boosters are to be provided with overspeed protection, where necessary.

1710 In d.c. constant pressure systems arrangements for generator and motor excitation are to be such that if the motor excitation circuit is opened by a switch or contactor the generator excitation is simultaneously interrupted or the generator voltage is immediately reduced to zero.

1711 VOLTAGES—No voltage limitations are specified.

Manœuvring Controls

1712 When two or more control stations are provided indicating lights are to be located at each control to indicate which station is in control.

1713 Where bridge or deck control is employed alternative control in the engine room is to be provided.

1714 Suitable interlocks, operating preferably by mechanical means are to be provided to prevent damage to the plant as a result of incorrect switching, such as the opening of switches or contactors not intended to be operated while carrying current.

1715 Provision is to be made for the manual operation without undue manual effort, of all manœuvring contactors, switches, field regulators and controllers. Where electric, pneumatic or hydraulic aid is used for normal operation, failure of such aid is not to result in interruption of power to the propeller shaft and any such device is to be capable of purely manual operation without delay. This latter requirement does not apply to bridge control equipment.

Alternative arrangements will be specially considered.

Cables

1716 Conductors in circuits essential for manœuvring or maintenance of propelling power are to be stranded having not less than seven strands and shall have a nominal cross sectional area of not less than 0·0045 sq. in. or 2,5 sq. mm.

1717 Cables which are connected to the slip rings of synchronous motors are to be suitably insulated for the voltage to which they are subjected during manœuvring.

1718 All joints are to be so made as to inhibit corrosion. They are to be arranged and supported in a manner suitable for withstanding the electro-mechanical forces due to short-circuit.

Overload and Short-Circuit Protection

1719 Provision is to be made for protection against severe overloads, and electrical faults likely to result in damage to the plant.

Earth Leakage Detection

1720 The main propulsion circuit is to be provided with means for detecting earth faults. For direct-current equipments exceeding 500 V and for all alternating-current equipments, aural and visual alarms are to be automatically operated on the occurrence of an earth fault, but the operation of such devices is not to interrupt the power supply. A switch may be provided to switch off the aural device, but in such cases the visual alarm shall remain switched on to indicate that the aural device is switched off. Alternative arrangements will be specially considered. If an earth connection is used for operating the detector arrangements then in direct-current systems the earth circuit is to be automatically opened in order to stop the circulation of fault current. In alternating-current systems the fault current is to be interrupted or limited to a safe value.

1721 Earth leakage devices are to be arranged to function for all earth faults exceeding 5 amp. In three-phase star connected alternating-current generators and motors with neutral points earthed, the earth leakage device shall operate on the occurrence of an earth fault in the windings of the machine, subject to the provision that 5 per cent of the coils at the neutral end of each phase may be left unprotected by the device. In high voltage a.c. systems where the capacitive leakage current is high consideration will be given to increasing this figure of 5 per cent.

1722 Excitation circuits are to be provided with lamps, voltmeters or other means to indicate continuously the state of the insulation of the excitation circuits under running conditions.

Discharge Protection

1723 For the protection of field windings and cables, means are to be provided for limiting the induced voltage when the field circuits are opened, or alternatively the induced voltage, when the field circuits are opened, is to be taken as the nominal design voltage.

1724 Where excitation is obtained from the auxiliary busbars means are to be provided to limit the voltage induced at the busbars when the auxiliary circuit-breaker or the distribution circuit-breaker opens.

1725 Shunt resistors which are connected across the field circuit of synchronous propulsion motors when they are functioning as asynchronous motors are to be suitably insulated for the voltage induced when reversing and are to be amply rated to allow for inadvertent delay during the reversing operation.

Safety Devices

1726 Where separately driven direct-current generators are connected electrically in series means are to be provided to prevent reversal of the direction of rotation of any of them on the failure of the prime mover.

1727 Where, on stopping or reversing the propeller, the regenerated energy transmitted by the propulsion motor is such as to cause a dangerous increase of speed in the prime mover means are to be provided for suitably absorbing or limiting such energy.

1728 Contactors and switches used for reversing the rotation of the propulsion motors are to be provided with means for forcibly opening them if they should inadvertently remain closed and they are to be so interlocked as to prevent the circuits for ahead and astern being closed simultaneously.

Alarms

1729 An aural alarm device is to be provided for machines having enclosed ventilating systems, arranged to operate in the event of the temperature of the heated air exceeding the predetermined safe value.

Identification

1730 All important circuits, instruments and apparatus are to be clearly labelled for identification.

Section 18

LIGHTNING CONDUCTORS

General

1801 Lightning conductors are to be fitted to each mast of all wood, composite, and steel ships having wooden masts or topmasts. They need not be fitted to steel ships having steel masts.

Construction

1802 In wood and composite ships fitted with wooden masts, the lightning conductors are to be composed of continuous copper tape and/or rope, having a section not less than 0·15 square inch (100 sq. mm.) which are to be riveted with copper rivets or fastened with copper clamps to a suitable copper spike not less than 0·5 inch (13 mm.) in diameter, projecting at least 6 inches (150 mm.) above the top of the mast. Where tape is used the lower end of the tape is to terminate at the point at which the shrouds leave the mast, and is to be securely clamped to a copper rope of not less than 0·5 inch (13 mm.) diameter. This copper rope is to be led down the shrouds and is to be securely clamped to a copper plate not less than 2 square feet (0,2 sq. m.) in area, fixed well below the light waterline and attached to the ship's side in such a manner that it is to be immersed under all conditions of heel.

1803 In wood and composite ships fitted with steel masts, each mast is to be connected to a copper plate in accordance with 1802, the copper rope being securely attached to and in good electrical contact with the mast at or above the point at which the shrouds leave the mast.

1804 In steel ships fitted with wooden masts, the lightning conductors are to be composed of copper tape or rope terminating in a spike, as set forth in 1802. At the lower end this copper tape or rope is to be securely clamped to the nearest metal forming part of the hull of the ship.

1805 Lightning conductors are to be run as straight as possible, and sharp bends in the conductors are to be avoided. All clamps used are to be of brass or copper, preferably of the serrated contact type, and efficiently locked. No connection is to be dependent on a soldered joint.

1806 The resistance of the lightning conductor, measured between the mast head and the position on the earth plate or hull to which the lightning conductor is earthed, is not to exceed 0·02 ohms.

Section 19

TRIALS

General

1901 Before a new installation, or any alteration or addition to an existing installation is put into service the following trials are to be carried out. These trials are in addition to any acceptance tests which may have been carried out at the manufacturers' works.

Insulation Resistance

1902 INSTRUMENTS—Insulation resistance is to be measured using a self-contained instrument such as a direct reading ohmmeter of the generator type applying a voltage of at least 500 V.

Where a circuit incorporates capacitors of more than two microfarads total capacitance, a constant-voltage type instrument is to be used to ensure accurate test readings.

(*a*) Power and Lighting Circuits—The insulation resistance between all insulated poles and earth and, where practicable, between poles is to be at least 1 megohm.

The installation may be sub-divided and appliances may be disconnected if initial tests produce results less than this figure.

(*b*) Internal Communication Circuits—Circuits operating at 50 V and above are to have an insulation resistance between conductors and between each conductor and earth of at least 1 megohm.

Circuits operating at less than 50 V are to have an insulation resistance of at least 0·33 megohm.

(*c*) Switchboards, Section Boards and Distribution Boards—The insulation resistance is to be at least 1 megohm when measured between each busbar and earth and between busbars. This test may be made with all circuit-breakers and switches open and all fuse links for pilot lamps, earth fault-indicating lamps, volt-meters, etc., removed and voltage coils temporarily disconnected, where otherwise damage may result.

(*d*) Generators and Motors—The insulation resistance of generators and motors, in normal working condition and with all parts in place is to be measured and recorded.

The test should be carried out with the machine hot, if possible. The insulation resistance of generator and motor cables, field windings and control gear is to be at least 1 megohm.

Earth Continuity

1903 Tests are to be made to verify that all earth continuity conductors are effective and that the bonding and earthing of metallic conduit and/or sheathing of cables is effective.

Performance

1904 It is to be demonstrated that the Rules have been complied with in respect of :—

Satisfactory commutation and performance of each generator throughout a run at full rated load.

Temperatures of joints, connections, circuit-breakers and fuses.

The operation of engine governors, synchronizing devices, overspeed trips, reverse-current, reverse-power and over-current trips and other safety devices.

Voltage regulation of every generator when full rated load is suddenly thrown off.

For a.c. and d.c. generators, satisfactory parallel operation and kW load sharing of all generators capable of being operated in parallel at all loads up to normal sea or harbour working load. For a.c. generators satisfactory parallel operation and kVA load sharing of all generators capable of being operated in parallel at all loads up to normal sea or harbour working load.

All essential motors and other important equipment are to be operated under service conditions, though not necessarily at full load or simultaneously for a sufficient length of time to demonstrate that they are satisfactory.

Propulsion equipment is to be tested under working conditions and operated in the presence of the Surveyors and to their satisfaction.

Voltage Drop

1905 Voltage drop is to be measured, where necessary, to verify that this is not excessive. (*See* M 813.)

Section 20

SPARE GEAR

2001 For the efficient operation of the ship the articles of spare gear mentioned in the following paragraphs, so far as they are applicable, should be supplied. Owners should arrange to replace or make good used items as opportunity occurs.

2002 One set of brushes and one set of bearings for one machine for each size of generator and for each size of motor engaged on essential services, such as those indicated below :—

Air compressors for heavy oil engines.
Scavenge blowers.
Air pumps.
Ballast pumps.
Bilge pumps.
Circulating and cooling water pumps.
Condenser circulating pumps.
Extraction pumps.
Feed water pumps.
Fire pumps.
Fuel valve cooling pumps.
Lubricating oil pumps.
Oil fuel pumps and oil fuel burning units.

Cargo refrigerating motors, including compressors, brine pump, circulating pump, fans, etc.
Fans for forced draught to boilers.
Steering gear.
Windlasses.
Ventilating fans for engine room and boiler rooms.
Oil separators.

Steering Gear

2003 For each size of steering gear motor and motor-generator if no standby electrical machine is installed, the following spare gear is required in addition to the spares for motors enumerated above :—

(i) Direct-current machinery :—

1 spare armature of each size fitted complete with shaft and half coupling.
1 spare field coil of each type fitted.

(ii) Alternating-current machinery :—

1 spare stator complete of each size fitted.

Fans for Refrigerating Equipment

2004 For electrically-driven air circulating fans the following spare gear will be required, in addition to the spares enumerated in 2002 for each size of motor installed, except where a duplicate fan motor in accordance with N 363 is installed :—

1 motor complete, or

Direct-current machinery :—
1 armature complete.
1 complete set of field coils.
1 complete set of brush gear.
1 set of bearings.

Alternating-current machinery :—
1 stator complete.
1 set of bearings.

Control Gear

2005 For the starting gear of motors, such as those enumerated in 2002 :—

1 set of contacts which are subject to burning or wear.

1 set of springs.

10 per cent of each different resistance element, but at least one of each.

1 of each type of shunt coil used for contactors, relays or low voltage release.

For six or less starters in which these parts are interchangeable it will be sufficient to provide one set of spares for the starter employing the greatest number of parts.

Switchgear and Distribution Boards

2006 For each type of circuit-breaker on each pole :—

1 set of contacts which are subject to burning or wear.

1 set of parts subject to wear.

1 set of springs.

1 shunt trip coil and 1 resistance element, of each kind used.

15 per cent but not less than six of each type of cartridge or other non-renewable fuses.

Rewireable fuse-handles; 5 per cent, with a minimum of one, of each size or type used, provided that not more than 12 need be supplied.

Navigating and Signal Lights

2007 Navigating and signal lights and their pilot lamps for indicating devices :—

1 complete spare set of lamps.

Emergency Lighting

2008 Where supplied from storage batteries of a voltage different from the ship's circuit :—

1 complete spare set of lamps.

Electric Couplings

2009 For each size of electric coupling used for propulsion purposes, the following is required as a minimum :—

1 complete set of brush gear.

1 field coil of each type fitted.

1 set of brushes for one coupling.

1 gauge for checking the magnetic air gap.

Spares for the control gear and switchgear as above.

Propulsion Equipment

2010 Owing to the varied characteristics of equipments an exact list of spares cannot be specified but the following should be provided as a minimum :—

(*a*) Generators, Motors and Exciters—One set of bearing bushes, with oil rings, if used, of each size

and type for the propulsion generators, motor and exciter.

Two lines of brush holders of each size and type.

One set of carbon brushes for one generator, exciter, and one motor.

One shunt field coil of each size and kind used for direct-current generators, exciter and motors.

One set of slip rings for one motor if of the alternating-current type.

(*b*) Switch and Control Gear

One set of contacts liable to burning or wear.

One set of springs.

10 per cent of each different resistance element, but at least one of each.

One of each type of shunt wound coil used for contactors, relays, or trip coils.

Two fuse handles of each type and size, or 15 per cent, but not less than six of each type of fuse.

20th July, 1961.

RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT

This document states recommendations for those features of the electrical installation which are not considered to be the concern of classification and therefore are not included in Chapter M. It should be clearly understood that these recommendations are not mandatory and are intended merely for the use of those Shipowners and Shipbuilders who may seek more guidance on equipment standards than is given in the Rules.

RECOMMENDATIONS FOR ELECTRICAL EQUIPMENT

Section 1

GENERAL

Earthing

Rule 108 The following items do not require to be earthed :—

(i) Lamp caps.

(ii) Shades, reflectors and guards supported on lighting fittings constructed of or shrouded in insulating material.

(iii) Metal parts or screws in, or through, insulating material which are thereby separated from current carrying parts in such a way that they cannot become live or come into contact with earthed parts.

(iv) Portable appliances having double insulation.

(v) Bearing housings which are insulated in order to prevent circulation of current in the bearings.

(vi) Clips for fluorescent lamps.

(vii) Cable clips.

(viii) Apparatus supplied at extra low voltage.

(ix) Fixed apparatus or parts of apparatus which, although not shrouded in insulating material is so guarded that it cannot be touched and cannot come in contact with exposed metal.

Section 2

SYSTEMS OF SUPPLY

It is recommended that in alternating current systems for socket outlets where special precautions against shock are necessary, e.g., portable boiler cleaning tools where the operator works in a confined space and his skin will be damp, the following maximum voltages should be used :—

(i) Supplied direct	55V
(ii) Where a safety isolating transformer is used supplying only one socket outlet	250V

Section 4

ROTATING MACHINERY

With the exception of machines for purely domestic purposes such as motors of vacuum cleaners, portable tools and galley equipment it is recommended that all machines comply with the requirements of M 4. Machines for domestic purposes should comply with a national or international standard.

Short Circuit

Sudden short circuit tests, when required by the purchaser, should be a matter for agreement between purchaser and manufacturer. If carried out they should be made at an initial terminal voltage not greater than the rated voltage of the machine and at rated frequency.

Field Regulation of Direct Current Generators

Rule M 418 This requirement will be met if at the conclusion of the full load temperature test, with full load current and normal full load voltage at the terminals when running at full load engine speed, the voltage across the shunt field regulator, with an ambient air temperature of 15° C., is not less than 14 per cent of the terminal voltage of the machine. This makes allowance for the difference in field resistance between average test conditions and the most severe service conditions.

Transient Voltage Response of Alternating Current Service Generators

Rule M 424 To meet this requirement it is recommended that one of the following alternatives be applied as determined by the characteristics of the installation, but such a test should not be required if evidence can be produced that a test has been carried out on a similar machine.

(a) When the starting kVA of the motors is 35 per cent or less of the capacity of the generating plant and where a rapid voltage recovery is not required.

With the generator driven at its rated speed at no load and giving its rated voltage under the control of the AVR, the maximum voltage change should not

exceed 15 per cent when a current equal to 35 per cent full load current at any power factor between zero and 0·4 lagging is suddenly drawn. The voltage should be restored to within 3 per cent of rated voltage in not more than 1·5 seconds.

(*b*) *When the starting kVA of the largest motor or group of motors liable to be started simultaneously exceeds 35 per cent but is less than 60 per cent of the capacity of the generating plant.*

With the generator driven at its rated speed at no load and giving its rated voltage under the control of the AVR the maximum voltage change should not exceed 15 per cent when a current equal to 60 per cent full load current at any power factor between zero and 0·4 lagging is suddenly drawn. The voltage should be restored to within 3 per cent of the rated voltage in not more than one second.

(*c*) *When the starting kVA of the largest motor or group of motors liable to be started simultaneously exceeds 60 per cent of the capacity of the generating plant, or when the recovery time of one second is not satisfactory for the operation of special devices supplied by the same generating plant.*

A specification of the performance of the generating plant should be agreed between purchaser and manufacturer.

Wattless Load Sharing

Rule M 426 This requirement may be otherwise stated:—

"When alternating current generators are operated in parallel the wattless loads of the individual generating sets should not differ from their proportionate share of the total wattless load by more than 10 per cent of the rated wattless output of the largest machine."

M 426 gives a more convenient method of measuring wattless load sharing but other methods can be used, e.g., measurement of power factor.

Frequency

When running alternating current motors from a shore supply of lower frequency care should be taken to lower the terminal voltage at the motors in proportion to frequency in order not to overload the motors.

Section 5

DISTRIBUTION

It is recommended that in machinery spaces, large galleys and such spaces as corridors, stairways leading to boat decks and public rooms, lighting should be supplied from at least two final sub-circuits one of which could be the emergency circuit so that failure of one circuit does not reduce the lighting to an inadequate level.

Steering Gear

Where electric power is used for the operation of steering gear it is recommended that failure of supply be indicated by audible and visual alarms in the engine room and/or pilot house.

In any steering gear where electric control only is used it is recommended that the control be duplicated.

Section 6

SWITCHBOARDS, SWITCHGEAR AND PROTECTIVE EQUIPMENT

All main and emergency switchboards should be provided with handrails in front of the panel. Where the switchboard is of the open type the rail should be non-conducting. The platform in front of and behind switchboards should have a non-slip surface.

Where necessary insulated handrails should be fitted behind switchboards and passageways behind switchboards should be provided with access doors at each end, these to be capable of being opened from the passageway. The doors should bear a prominent and permanent notice giving the maximum voltage.

For voltages between poles or to earth exceeding 250V direct current or 55V alternating current, switchboards should be of the dead front type. Where the voltage exceeds 55V during operation an insulating mat should be provided.

Where an earth indicating system using either two or three lamps is used the lamps should be of metal filament type each not exceeding 30W. They should be of the same colour and placed not more than 6 in. apart.

For preference tripping systems the following overcurrent settings are recommended (expressed as a percentage of the rated current of the generator or circuit to be protected).

Main generator circuit breaker	150 per cent
Preference tripping relays	110 per cent

Time delays should be established in accordance with the nature of the load the following values being given as an example :—

First tripping circuit breaker	5 sec.
Second tripping circuit breaker	10 sec.
Third tripping circuit breaker	15 sec.
Main generator circuit breaker	20 sec.

For overloads less than 10 per cent protection may consist of an alarm signal operated by a time delayed relay set to approximately 110 per cent rated current of the generator.

Two-wire circuits of rating exceeding 100A should be controlled as a minimum in one insulated pole or phase by a switch. Three-wire alternating current circuits rated at more than 60A should be controlled by a triple-pole linked switch.

The minimum operating current of every circuit breaker should be not greater than twice the rating of the smallest conductor which it is installed to protect except for motor circuits where short circuit protection only is required (in these cases three times the cable rating).

The overcurrent setting of a circuit breaker will depend on individual arrangements and in motor circuits must be matched to the load temperature characteristics of the motor, the following figures being given merely as an example :—

	Overcurrent
Continuously rated circuits	25 per cent
Intermittently rated circuits	50 per cent
Steering gear and emergency circuits	200 per cent

Circuit breakers, contactors and switches should be so installed that, as far as practicable, their moving parts and associated relays are not live when the circuit breaker or contactor is in the OFF position.

Circuit breakers and contactors should be provided with a means of isolation.

In large installations, where fault levels are high, circuit breakers should be of the power operated type.

In earthed systems of large capacity, protection against internal faults in the generators should be considered.

All generators arranged for parallel operation with one another or with the shore power feeder should be provided with undervoltage release which prevents the closing of the appropriate circuit breaker until the generator terminal voltage reaches at least 70 per cent of the rated voltage.

The installation of automatic circuit opening devices, other than for short circuit protection, is not recommended in exciter circuits.

In alternating current systems consideration should be given to the fitting of an automatic trip to main generator circuit breakers which will open the breaker on loss of excitation.

The fitting of an ammeter in exciter circuits is recommended.

Selection of Fuses

(i) Fuses for steady load circuits, such as heating circuits, should be of current rating at least equal to that of the apparatus. If other overcurrent protection is provided or if discrimination requires it, a fuse of greater current rating may be necessary.

(ii) Fuses for fluctuating load circuits, such as motor circuits, transformer circuits, lighting circuits and capacitor circuits, should have a time/current characteristic which allows the transient overcurrent to be carried without operation of the fuse. It will sometimes be necessary to select fuses of a current rating greater than that of the circuit.

For motor circuits it will be necessary to obtain particulars of the magnitude and duration of the starting current and to select fuses by referring to the time/current characteristics.

Section 8

CABLES

In large installations where short circuit currents may be high it is recommended that cables are armoured and in three-phase installations, as far as is practicable three-core cables carrying the three-phase currents should be employed.

Where these precautions are necessary particular care should be taken with the cable supports especially at the ends of cables.

In 110V installations where lighting cables may be fully loaded, are bunched together and are installed between wooden panelling or similar locations it is recommended that the minimum size of conductor be not less than ·003 sq. in. (2,5 sq. mm.).

Section 10

LIGHTING

In bathrooms, galleys, laundries and similar places the parts of a lampholder likely to be touched should be constructed of or shrouded in insulating material and fitted with a protective shield or totally enclosed fittings should be used.

Lighting switches for bathrooms and similar locations should be outside such spaces unless they are of construction suitable for humid conditions.

Lamps which are used near combustible material should be installed in totally enclosed fittings.

Where tubular fluorescent lighting is used, lighting by one or more filament lamps should be provided, especially in compartments containing running machinery.

Lamps which are used in spaces liable to contain explosive or inflammable materials should be installed in flameproof fittings.

Filament lamps are recommended for emergency lighting.

Live parts of fluorescent lighting installations should be screened with earthed metal or insulating material.

Connections to Lighting Fittings

Due to the reduced physical sizes of lamps in many countries, e.g., 100W lamps can now be installed in many fittings that previously were designed for 60W lamps care must be taken with cable connections so that the maximum conductor temperature is not exceeded. Tests carried out in the past have shown a temperature rise at some lampholder terminals of 80° C. and a distance about 0·625 in. (16 mm.) from the lampholder terminals exhibited a temperature rise of 60° C.

Where cables operate at temperatures in excess of the permitted maximum, deterioration of the insulation occurs with premature failure in service.

Comments on the behaviour of the various classes of insulation are given below :—

(*a*) Rubber

Maximum conductor temperature 60° C. At higher temperatures it ages with increasing severity, reducing its life.

(*b*) Polyvinyl Chloride

Maximum conductor temperature 60° C. At higher temperatures it may flow away from the conductor when under pressure, e.g., clips.

(*c*) Polychloroprene

This is usually associated with rubber when maximum conductor temperature is 60° C. At higher temperatures it absorbs moisture after cooling leading to electrical breakdown.

(*d*) Butyl

Maximum conductor temperature 80° C. At 130° C. it ages rapidly and may turn into a powder which can fall away from the conductor if subject to vibration or shock.

(*e*) Silicone Rubber

Maximum conductor temperature 150° C. and intermittently up to 200° C.

Fittings should be designed so that the maximum permitted temperature for the cable is not exceeded. Alternatively high temperature tails (e.g., silicone rubber) should be incorporated in the fitting and led to a terminal block.

Section 11

ACCESSORIES

Where differing distribution systems are used any socket outlets and plugs should be of such design that incorrect connection cannot be made.

In general socket outlets should not be fitted in bathrooms, lavatories and similar wet places.

In systems at 110V direct current and above or 55V alternating current and above socket outlets and plugs should be provided with an earthing contact. This contact should make contact before the live pins when the plug is inserted.

Heating and Cooking Equipment

Electric heating and cooking equipment should be so constructed that parts which must be handled cannot exceed 55° C.

Heating elements should be readily replaceable.

Connections between elements, switches and supply cables should be carried out with terminals.

Connections between elements and between elements and terminals to which insulated cables may be connected, unless self-supporting and rigidly secured in position should be continuously insulated with incombustible material.

Heating elements should be suitably guarded. Live parts of cooking appliances should be protected so that cooking utensils cannot come into contact with them.

Space heaters in cabins, lockers, etc., should be of the convector type. Space heaters should not be installed in spaces where inflammable gases might accumulate.

Batteries

Batteries should be located where they are not exposed to excessive heat or extreme cold. Batteries for emergency service, including emergency diesel engine starting should be located above the bulkhead deck. The best operating conditions for batteries are obtained when the working temperature is between 15° C. and 27° C. Where practicable the temperature of the electrolyte should not be permitted to exceed 50° C. since higher temperatures tend to reduce the life of the battery. Low temperatures may temporarily reduce the capacity of the battery.

Mechanical ventilation of battery rooms should be capable of changing the air in the battery room four to five times per hour.

Spare Gear

The provision of an insulation tester is recommended.

Section 16

SPECIAL REQUIREMENTS FOR OIL TANKERS

Flameproof and Intrinsically Safe Equipment

It is sometimes stated that flameproof equipment should be permitted in dangerous spaces, e.g., cargo pump rooms, but this cannot be agreed except as stated in Section 16. Flameproof equipment is flameproof when it leaves the manufacturers' works and after a period of service may no longer be flameproof, due to faulty or inadequate maintenance.

Flameproof lighting fittings are permitted in pump rooms, only because many pump rooms are so large that they cannot be adequately lit through glazed ports.

Intrinsically safe equipment and the circuit to which it belongs is to be physically separated from all other circuits. This is because the certificate of intrinsic safety involves both the equipment and its circuit.

Chapter N

REFRIGERATED CARGO INSTALLATIONS

Extract from Chapter B for reference

B 901 On application from Owners, refrigerated cargo installations which comply with Chapter N of the Rules and are favourably reported on by the Surveyors will be assigned an appropriate class in accordance with N 1. Certificates will be issued and the class notation, together with the particulars of the installation, will be entered in the Supplement.

B 902 The class assigned will be retained provided the installation is found to be in a good and efficient condition at the Periodical, Loading Port, and other Surveys set forth in N 8.

Section 1

GENERAL

Class Notation

101 The class notation assigned will be Lloyd's RMC followed by the minimum temperature(s) approved by the Committee for the installation with the maximum sea temperature stated, e.g. "to maintain temp. 10° F. in the lower and 31° F. in the upper chamber with sea temperature 85° F. maximum."

NOTE.—The temperature at which the cargo is to be carried is not the responsibility of the Society.

102 Installations constructed under the Society's Special Survey in accordance with N 2 to N 6 will be eligible for the distinguishing mark ✠ before the class notation, thus ✠Lloyd's RMC. In other cases the mark ✠ will not be assigned.

103 In the case of installations designed to reduce the temperature of non-precooled cargoes a mark ‡ will be shown under the class notation in the Appendix to the Register Book and will be included on the certificate as an indication that an installation has been considered by the Society for this duty. A special statement showing the cargo cooling capabilities of such installations, in respect of stated weights and descriptions of cargoes under stated conditions, will be issued on application by the Owners to the Society's Head Office.

Special Cases

104 The Committee will be prepared to give consideration to cases of ships engaged on voyages of short duration, to installations of small capacity, or to other special circumstances. In such cases the class may include a service limitation or other restriction.

Refrigerants

105 These Rules are applicable to the following primary refrigerants:—

Carbon Dioxide
Ammonia
Dichlorodifluoromethane
Monochlorodifluoromethane

Proposals to use other refrigerants will be specially considered on application, but methyl chloride will not be accepted.

NEW INSTALLATIONS

Section 2

SPECIAL SURVEY DURING CONSTRUCTION

201 New installations intended for classification are to be constructed under the Society's Special Survey in accordance with the requirements of N 3 and N 4; tests are to be carried out as specified in N 5, and spare gear is to be supplied as listed in N 6.

Information and Plans to be Submitted

202 The following information and plans are to be forwarded for consideration before construction is commenced:—

(*a*) Refrigerating plant—standard data sheet in duplicate. (Copies of this data sheet may be obtained from the Society's local office.)

(*b*) Refrigerating plant — detailed specification in triplicate.

(*c*) Insulation—detailed specification in triplicate.

(*d*) General arrangement of insulated chambers in elevation and plan. The plans are to be to a scale of not less than $\frac{1}{4}$ inch to the foot and adequate for the measurement

of the external surfaces and the deck and bulkhead edges. Dimensions and spacing of frames, beams and stiffeners and details of other steel work protruding into the insulation and within the chambers are to be shown. Oil fuel and liquid cargo tanks adjacent to or below the chambers are to be indicated, and whether heating is provided for such tanks. Ventilating and air conditioning trunks and ducts passing through chambers are to be shown. The plans should include a diagram showing the position of the chambers in relation to other parts of the ship if this is not otherwise apparent.

(*e*) Detailed plans showing the thickness and methods of attachment of the insulation and linings on all surfaces, including girders, hatch coamings and pillars; details of insulated doors, and hatch, access, bilge and manhole plugs and their frames. Method of attachment of brine or direct expansion grids and meat rails are also to be shown.

(*f*) Arrangement of air ducts (including method of cooling spaces within hatch coamings), air coolers, fans and their motors.

(*g*) Air cooler defrosting arrangements, other than hot brine circulating systems.

(*h*) Arrangement of brine grids including those in way of hatches; and method of construction.

(*i*) Arrangement of chamber thermometers.

(*j*) General arrangement of refrigerating machinery.

(*k*) Brine circuit diagram with particulars of piping.

(*l*) Primary refrigerant gas and liquid circuit diagrams and full particulars of all pressure piping.

(*m*) Sectional arrangement of refrigerant compressors.

Detailed dimensioned plans of:—

(*n*) Compressor crank shafts.

(*o*) Compressor crank cases where exposed to the refrigerant pressure.

(*p*) Condensers.

(*q*) Evaporators (brine coolers).

(*r*) Air coolers.

(*s*) Oil separators.

(*t*) Liquid receivers.

(*u*) All other pressure vessels.

NOTE.—All the plans listed, and any others which may be specially requested are to be forwarded in triplicate.

(*v*) Similar plans are required for refrigerating plant of other designs.

(*w*) Where the refrigerating machines are driven by oil engines particulars and plans are to be submitted in accordance with the requirements of G 104 and H 7.

(*x*) Where the refrigerating machines or air cooler fans are driven by steam engines particulars and plans are to be submitted in accordance with G 104.

(*y*) Where air cooler or necessary air stirring fans are electrically driven plans of the motors are to be submitted in accordance with M 430.

Refrigeration required in excess of N 306

203 Refrigeration required in excess of that specified in N 306, which may be necessary for rapid cooling of chambers, or cooling cargoes loaded at temperatures above the carrying temperature, is to be in accordance with a specification approved by the Owners.

Rate of Air Circulation

204 Where refrigeration is effected by forced air circulation over coolers the proposed fan output in each chamber will be considered in relation to the heat to be removed, the nature of the cargo and the service(s) intended.

Where chambers are intended for the additional duties mentioned in 203 the rate of air circulation is to be in accordance with the Owners' requirements.

Subsequent Modifications or Additions

205 Any subsequent modifications or additions to particulars and/or arrangements shown on the approved plans or in the specifications are also to be submitted for approval.

Novel Arrangement and Designs

206 Where the proposed construction of the refrigerating plant or refrigerated chambers is novel in design or involves the use of unusual material, special tests may be required, and a suitable class notation may be assigned when the Committee consider this necessary.

Survey Requirements

207 From the commencement of the construction and installation of the refrigerating plant and of the insulation and fitting out of the cargo chambers, to the testing of the completed installation, the Surveyors are to examine the materials and workmanship and are to indicate at the earliest opportunity and require the rectification of any items not in accordance with the Rules or the approved specifications and plans, or any material, workmanship or arrangement found to be defective or unsatisfactory.

Section 3

REFRIGERATING PLANT

Definition of a Unit

301 A refrigerating unit comprises a prime mover, one or more refrigerating machines (refrigerant gas compressors), one gas condenser—and in the case of a secondary refrigerant, one brine cooler (gas evaporator)—and the fittings necessary to permit independent operation of the unit.

302 If the prime mover of a refrigerating machine is a steam engine with two or more cylinders and each cylinder drives a corresponding compressor, or there is more than one motor similarly arranged, and if each compressor is connected to its own condenser and brine cooler (where fitted), the arrangement is to be regarded as two or more units as the case may be, provided the units can be used separately or in combination.

NOTE.—Condensers or evaporators of the coil-in-casing type need not necessarily be in separate casings.

303 Two or more refrigerating machines (or compressors) driven by a single prime mover, or having only one condenser or one brine cooler (where fitted), are to be regarded as one unit.

304 Where a refrigerating plant is provided for sub-cooling the liquid refrigerant, or cooling the condensers of other refrigerating machines, and is not arranged for cooling the cargo spaces independently, it will not be regarded as a unit.

305 Where a refrigerating plant is dependent on the main refrigerating units for cooling the condenser or the refrigerant liquid, it will not be regarded as a unit.

Refrigeration to be Provided

306 The refrigeration provided is to be capable of efficiently maintaining the minimum temperature(s) under the conditions applicable to the maximum sea temperature for which approval by the Committee is desired and which is to be specified in the class notation (*see* N 101), when working 24 hours a day with any one of the refrigerating units out of action. It is recommended that a reasonable margin in plant output over maximum load be allowed for possible overall inefficiencies under service conditions.

307 Where part of the necessary refrigeration is obtained by the sub-cooling of the liquid refrigerant by other refrigerating plant, one plant supplying such sub-cooling may be considered sufficient provided the refrigerating units including the stand-by unit are capable of the full duty specified in 306 in the event of the sub-cooling plant being out of action.

308 In any case where all the refrigerating units are not connected for use on all the refrigerated cargo chambers the plant serving each chamber is to comply with the requirements of 306.

309 The foregoing requirements are based on the assumption that installations will have relatively few refrigerating units each arranged to serve all chambers. In the case of installations having a large number of small units arranged to serve individual chambers, or groups of chambers, the question of reserve plant will be the subject of special consideration.

Number of Refrigerating Units

310 Not less than two complete refrigerating units are to be fitted. Where two units only are fitted the working parts are to be interchangeable.

Stand-by Pumps

311 A stand-by gas condenser cooling water pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306. This stand-by pump may be one of the pumps used for other purposes provided it is of adequate capacity and its use on the gas condenser does not interfere with other essential services.

312 Where brine is used for refrigerating the cargo chambers a stand-by brine circulating pump is to be installed ready for use in addition to the pumps required for the full duty specified in 306.

Sea Connections

313 Condenser cooling water is to be taken from not less than two sea connections, one of which may be that provided for other purposes, such as the water ballast inlet. It is recommended that one of the sea connections be provided on the port and the other on the starboard side.

Location of Machinery

314 Where ammonia refrigerant is used the refrigerating machinery is to be in an efficiently ventilated compartment isolated from the propelling machinery spaces and shaft tunnels, and living quarters.

Machinery using non-toxic and non-inflammable refrigerants will not be subject to restriction on location in general, but proposals to install relatively large plants in propelling machinery spaces will require special consideration.

Prime Movers

315 Where refrigerating plant is electrically driven the motors and their control gear are to comply with the requirements of M 4 and M 7.

316 Where the refrigerating machinery is steam driven the steam engines are to comply with the requirements of Chapters G and H and the exhaust steam is to be led to the main and auxiliary condensers.

317 Where the refrigerating machinery is driven by oil engines the requirements of Chapters G and H are to be carried out.

Motive Power

318 In the case of 315 the electric power is to be taken from at least two generators (*see also* M 403) and in the case of 316 steam is to be taken from at least two boilers, each capable of the maximum duty without interference with other essential services.

Plant on Ships not classed with the Society

319 In the case of refrigerating installations being constructed under the Society's Special Survey on ships not intended to be classed with this Society, the generator engines and electrical equipment, which supply power to the refrigerating installations, should be constructed in accordance with the requirements of the Classification Society concerned, but such plant is to be examined generally and under working conditions.

Steel Castings

320 Important steel castings are to comply with the requirements of P 5.

Steel Forgings

321 Crank shafts and other important steel forgings are to comply with the requirements of P 6.

Dimensions of Crank Shafts

322 Crank shafts of single acting reciprocating refrigerant compressors, of mild steel having a tensile breaking strength of 28/32 tons per square inch are to have dimensions not less than those calculated from the following formulæ.

323 The formulæ are applicable to compressors operating on the normal cycle, with crank shafts having one, two, three or four cranks at equal angles and one cylinder acting on each, and with two or more main bearings.

324 The formulæ are also applicable to compressors, other than CO_2, having the crank and cylinder arrangements as shown in the following table, but in these cases the calculated shaft diameter is to be increased by 5%, 18% and 25% when the angle between cylinders is 90°, 60° and 45° respectively.

Number of crank pins	Number of cylinders per crank	Angle between cylinders
1 or 2	2	45°, 60° or 90°
3	2	45° or 60°
4	2	45° or 60°
1	3	45°, 60° or 90°
2	3	45° or 60°
3	3	45°
1	4	45° or 60°
2	4	45°

325 The formulæ are not applicable to crank shafts having more than one crank on the same top centre, or to compressors where the cylinders are arranged for supercharging by gas of higher pressure at an intermediate stage of the stroke.

Diameter of Crank Shafts

326

Refrigerant	Diameter of crank shaft (All dimensions in inches or millimetres)
Carbon Dioxide (CO_2)	$\sqrt[3]{\frac{D^2\left(15\frac{ab}{a+b}+1{\cdot}25S\right)}{12}}$ for gas discharge pressures up to 1500 lb. per square inch.
Ammonia (NH_3) Monochlorodifluoromethane ($CH\,Cl\,F_2$)	$\sqrt[3]{\frac{D^2\left(2{\cdot}5\frac{ab}{a+b}+0{\cdot}15S\right)}{12}}$ for gas discharge pressures up to 250 lb. per square inch.
Dichlorodifluoromethane ($C\,Cl_2\,F_2$)	$\sqrt[3]{\frac{D^2\left(1{\cdot}5\frac{ab}{a+b}+0{\cdot}1S\right)}{12}}$ for gas discharge pressures up to 150 lb. per square inch.

where D=cylinder diameter,

S=length of stroke,

a=distance from the inner edge of one bearing to the centre line of the crankpin nearest the centre of the span,

b=distance from the centre line of the same crankpin to the inner edge of the other bearing,

a+b=distance (or span) between the inner edges of adjacent main bearings.

Crank Webs

327 Crank webs are to be of the following proportions or of equivalent strength:—

Breadth of web = 1·33 × calculated shaft diameter.

Thickness of web adjacent to a bearing = ·56 × calculated shaft diameter.

Thickness of intermediate webs = ·75 × calculated shaft diameter.

Crank Shafts of Other Materials

328 Where crank shafts are proposed to be made of steel of greater strength or of other material, the particulars including the material specification are to be submitted for special consideration.

Crank Shafts for Compressors of Other Designs

329 The particulars of crank shafts for double acting or compound compressors, and for other refrigerants or arrangements, are to be submitted for special consideration.

Maximum Working Pressures

330 The components of primary refrigerant pressure systems including piping, stop valves and headers are to be designed for a maximum working pressure of not less than:—

1500 lb. per square inch for carbon dioxide (CO_2)

250 lb. per square inch for ammonia (NH_3) and monochlorodifluoromethane ($CH\ Cl\ F_2$)

150 lb. per square inch for dichlorodifluoromethane ($C\ Cl_2\ F_2$)

In the case of crankcases which are exposed to the refrigerant pressure the design pressure is to be not less than:—

200 lb. per square inch for ammonia and monochlorodifluoromethane

100 lb. per square inch for dichlorodifluoromethane

Crankcases designed for a lower pressure are to be provided with a pressure relief valve arranged to lift at the design pressure and the discharge led to a safe place.

If desired a lower design pressure may be considered for other parts of the low pressure side of the system.

The design pressure for other refrigerants which may be proposed will be considered on application, but as a general guide this will be the saturated vapour pressure at 115° F.

Refrigerant Pressure Vessels

331 Welded cylindrical pressure vessels which are of steel construction and exposed to the pressure of the refrigerant are to be constructed in accordance with the requirements of J 18 to J 23 so far as applicable, except that the pressure tests are to comply with 339.

332 Where ammonia is the refrigerant, pressure vessels are to be constructed to not less than Class 2 fusion welded or Class 1 forge welded requirements.

333 Where pressure vessel shells are made of steel tube the tubes are to comply with the requirements of E 5 so far as applicable, except that the formula for determining the thickness of straight shells may be modified to

$$t = \left(\frac{WP \times D}{2f} + \cdot 03\right) 1 \cdot 15$$

334 Where ammonia is the refrigerant, pressure vessel shells are not to be manufactured from lap welded pipes.

335 Where pressure vessels are of seamless construction, they are to comply with the requirements of J 2405 to J 2407, and the pressure tests are to comply with 339.

336 Where it is proposed to construct pressure vessels of materials other than steel, or not of cylindrical form, full particulars will be required for special consideration.

Pressure Pipes

337 Steel piping for primary refrigerants is to comply with the requirements of E 5 except that the figure of ·05 may be reduced to ·03 and the pressure tests are to be in accordance with 339.

Butt welding of pipe lengths in lieu of flanged joints is to be carried out by an approved method, under the supervision and to the satisfaction of the Society's Surveyors, including such weld tests as may be required.

Where the pipes are galvanised, a short part at the ends about 4 inches long, is either to be left ungalvanised or the galvanising is to be removed before welding.

338 Where it is proposed to use pipes of materials other than steel, full particulars are to be submitted for consideration.

Pressure Tests

339 The pressure tests which follow are to be witnessed by the Society's Surveyors at the maker's works. The hydraulic test may be carried out with any suitable liquid. When it is inconvenient to test large NH_3 (ammonia)

condensers and evaporators by submersion in water the shells may be charged with air and gas, and tested by some suitable means. In the case of C Cl_2 F_2 (dichlorodifluoromethane) and CH Cl F_2 (monochlorodifluoromethane) a suitable gas may be used in lieu of air.

Refrigerant	Component	Minimum Test Pressure lb/in²	
		Hydraulic	Air*
CO_2	Compressor cylinder blocks, stop valves and connections, connecting piping, separators, condenser and evaporator coils and all components subject to gas pressure.	3,000	1,500
$N.H_3$ and CH Cl F_2	Compressor cylinders, stop valves, connections and all piping.	600	300
	Compressor crankcases subject to refrigerant pressure.	300	150
	Condenser, evaporator and air cooler coils.	1,500	500
	Condenser and evaporator coils or grids welded to headers; condensers and evaporators of double pipe or "shell and tube" types; pressure vessels, and all other components subject to gas pressure.	500	250
C Cl_2 F_2	Crankcases subject to refrigerant pressure.	200	150
	Small machines with cylinders up to 4½" dia. where the cylinders and crankcases are in one casting.	300	200
	All other components in the entire system, including piping.	350	200
	Cooling liquid side of refrigerant condensers.	2WP but not less than 15	
Brine	Air cooler coil assembly.	100	
	Cast iron casings of refrigerant evaporators.	2WP but not less than 15	
	Steel casings of refrigerant evaporators on suction side of pump.	2× head pressure but not less than 30	
	Steel casings of refrigerant evaporator on discharge side of pump.	2WP but not less than 50	
	Open casings of brine evaporators.	Filled to top	

* Component submerged in water at 90° F.

Tests after Erection on Board Ship

340 Carbon dioxide systems are to be examined for gas leaks when the system is charged. Ammonia and monochlorodifluoromethane systems are to be tested to a gas or air pressure of not less than 200 lb. per square inch.

Dichlorodifluoromethane systems are to be tested by a suitable gas to a pressure of not less than 100 lb. per square inch.

Brine systems are to be tested to a hydraulic pressure of double the working pressure but not less than 50 lb. per square inch. Where the hydraulic test is not reasonably possible, sections of brine leads (service pipes) which have to be insulated before the circuits are complete may be tested by an air pressure of 90 lb. per square inch.

Oil Separators

341 Suitable oil separators with drains are to be provided to the refrigerant lines. If wire gauze is used in the separator it is to be sufficiently robust and supported to prevent disintegration.

Filters (strainers)

342 Suitable filters are to be provided in the refrigerant gas lines to compressors and in the liquid lines to the regulators. Wire gauze in filters is to be sufficiently robust and supported to prevent disintegration. A filter may be combined with the oil separator required by 341.

Refrigerant Driers

343 Driers are to be fitted in monochlorodifluoromethane and dichlorodifluoromethane refrigerant systems, and the arrangement is to be such that the drier can be by-passed, isolated and opened up without interrupting plant operation.

Brine Systems

344 Where brine is the cooling medium it is recommended that the "closed" system with a brine balance tank be adopted in every case.

Safety Devices

345 A pressure relief valve and/or safety disc is to be fitted between each compressor and its gas delivery stop valve, the discharge being led to the suction side of the compressor.

346 All pressure vessels of refrigerant systems which could become filled with liquid refrigerant and isolated are to be provided with safety discs and relief valves in series, or other approved arrangements, the discharge being led to a safe place above deck.

347 Suitable spring-loaded safety valves are to be provided to the cooling liquid side of condensers and the brine side of evaporators where the pressure from any pump connected could cause a pressure in excess of the maximum working pressure.

Access to Plant

348 The arrangements are to be such that all components of the refrigerating machinery can be readily opened up for inspection or overhaul. Space is to be

provided for the withdrawal and renewal of the tubes in "shell and tube" type evaporators (brine coolers) and condensers.

349 Where the coils of "coil-in-casing" type evaporators (brine coolers) and condensers are unwieldy and cannot readily be withdrawn, two suitably arranged inspection holes are to be provided in the top plate, in the sides at about half height and in the sides at the bottom. The holes are to be as large as practicable and not less than 9 inches × 6 inches.

Manual Control

350 Where plants are operated by thermostatic refrigerant control, efficient manual controls are also to be provided, and the arrangement is to be such that thermostatic controls can be by-passed and isolated.

Refrigerating Plant of Other Design

351 Particulars of refrigerating plant of designs other than those mentioned in these Rules (e.g., steam jet vacuum refrigeration plants) are to be submitted for special consideration.

Cooling Appliances in Refrigerated Chambers

352 Chambers may be refrigerated by pipe grids on the ceiling and sides or by the circulation of air over coolers.

353 Refrigeration by pipe grids in the chamber is to be effected by the circulation of brine, except in the case of installations or chambers of very small capacity when the direct expansion of the refrigerant will be considered. The pipe grids in each chamber are to be arranged in not less than two sections. Each section is to be fitted with valves or cocks so that it can be shut off.

354 Either brine or the direct expansion of the refrigerant may be employed in the coils of air coolers. The coils are to be arranged in not less than two sections each of which is to be capable of being readily isolated when necessary.

355 The brine or direct expansion leads to, and returns from, the cooling appliances in each chamber are preferably to be in duplicate.

356 In order to minimize the dehydration of the cargo and the frosting of the cooling elements, it is recommended that the cooling appliances in each chamber should be designed to maintain the required minimum temperature under the maximum external conditions with a mean temperature difference of not more than 8° F. between the cooling medium and the chamber.

357 Where the joints of brine pipes are made by screwed couplings, the pipes, coupling and back nut threads are to be a good fit and the thickness of the pipes at the bottom of the screw thread is to be not less than 3/32nds of an inch.

358 Where the joints of air cooler and grid piping are butt welded they are to comply with 337.

359 Steel brine and refrigerant piping, grids, joint sleeves and coils within the refrigerated cargo chambers, or where embedded in insulation, or individually insulated are to be galvanized externally. Where such pipes are connected by screwed couplings or by butt welds, the screw threads clear of the couplings or the butt welds and the adjoining ungalvanized portions of the piping, are to be suitably coated and taped after pressure testing to prevent corrosion. The locations of the joints are to be marked on the outside of the insulation.

360 Brine tanks and piping should not be galvanized on the brine side. In cases where any parts of the brine system are so treated, the brine cooling and return tanks, if closed, are to be provided with a ventilating pipe or pipes led to the atmosphere in a location where no damage will arise from the gas discharged, and the ventilating pipes are to be fitted with wire gauze diaphragms which can readily be removed. Where the brine tanks are not closed, the compartments in which they are situated are to be efficiently ventilated.

361 Means are to be provided for defrosting air coolers.

362 Air coolers are to be provided with trays of suitable depth arranged to collect all water condensate. The trays are to be provided with drains at the bottom so that the whole of the condensate can be drained away when the chambers are in service.

363 Access arrangements to air cooler fans and fan motors are to be such that both fans and motors may be readily removed for repair or renewal when the chambers are loaded with refrigerated cargo. Access for servicing only is required in cases where duplicate fans and motors, each capable of the full duty, are installed ready for use; this also applies to centrifugal type fans but not to their motors.

364 The air circulation system is to be arranged for positive air delivery to, or suction from, all parts of the chamber, including any space within hatch coamings.

365 Where it is intended to carry fruit cargoes, which may be adversely affected by low temperatures, into sea areas where the temperature may be below the carrying temperature, facilities for heating the chambers are to be provided.

Air Refreshing Arrangements

366 Where chambers are intended for the carriage of gas generating cargoes, air refreshing appliances are to be provided.

The position of the air inlets is to be carefully selected to minimize the possibility of vitiated air from any source entering the chambers. Each chamber is to be provided with individual inlets and discharges, having airtight closing appliances.

Section 4

CARGO CHAMBERS

Construction

401 Each individual chamber is to be of steel construction throughout and hose-tested for tightness, or tested more thoroughly by gas and air under slight pressure when required by the Owners.

402 At the request of Owners, special consideration will be given to the construction of divisional bulkheads of materials other than steel, between refrigerated cargo chambers where the chambers concerned are intended for cargoes which will not taint or otherwise adversely affect the cargo in any other chamber.

NOTE.—Gases given off by one description of fruit may adversely affect other descriptions by promoting rapid ripening.

403 Hatch plugs and their supports, chamber, air cooler and other access doors, tonnage openings, bilge limbers and plugs are to be made as airtight as possible.

404 Ventilators, ducts or pipes passing through refrigerated chambers to other compartments are to be made airtight and efficiently insulated. Ventilators to refrigerated spaces, if fitted, are to be provided with airtight closing appliances.

Airtightness of the Bulkheads and Decks

405 Where refrigeration pipes pass through bulkheads or decks of refrigerated cargo chambers they are not to be in direct contact with the steelwork, the holes through which they pass are to be true and of suitable finish for effectively sealing by the method intended. It is recommended that holes be trepanned and not burnt out. The airtightness of the bulkheads and decks is to be maintained (*see also* 408 and 413).

Airtightness of Chambers

406 The foregoing paragraphs, 401 to 405, are mainly concerned with infiltration of odours, gases, water vapour and air, which may taint or adversely affect the refrigerated cargo or the insulation, or cause undesirable frosting of cooling equipment. With this object in view it is also recommended that insulation lining, bilge limbers and plugs, hatch plugs, chamber and access doors be constructed of water vapour resisting material, or covered with such material, and sealed, where exposed to bilges or external conditions.

Insulation

407 Steelwork is to be thoroughly cleaned and coated in accordance with D 3003 and D 3004 and is to be examined for airtightness of fittings before insulation is applied.

Insulating material approved by the Committee is to be used throughout, and the thickness of insulation over all surfaces and the manner in which it is supported are to be in accordance with the approved specification and plans.

The insulation is to be efficiently packed and, where it is of slab form, the joints are to be butted closely together and staggered, unavoidable crevices being filled with insulating material. Bitumen should not be used for filling crevices.

408 Pipes carrying the refrigerating medium are not to be in contact with the steel structure and are to be effectively insulated outside the chambers they serve, except within insulated brine cooler and control rooms (*see also* 405 and 413).

Cross-references

409 For insulation of oil storage tank tops and bulkheads, *see* E 341 and E 342.

For pipes in refrigerated spaces, *see* E 416 to E 418.

For drainage of refrigerated spaces and cooler trays, *see* E 211 to E 216.

Protection of Insulation

410 The insulation in way of the hatchways and about 2 feet beyond on the tank top and the tunnel top is to be protected with hardwood sheathing about 2 inches thick, or to have similar protection.

Access Plugs and Panels

411 Insulated plugs are to be provided in the insulation where required for easy access to the bilges, bilge suction roses, cooler and space drains and tank manhole doors. Removable panels are to be provided for access to tank air and sounding pipes and drains.

It is recommended that, where no air space is provided below the insulation on the tank tops and the floor covering above the insulation is reinforced asphalt, a number of small insulated inspection plugs be fitted for leakage detection.

Where "loose fill" insulation is fitted and lined with metal it is recommended that airtight inspection plates be provided at the top of vertical surfaces to facilitate inspection and making good any settlement.

Fire-resisting Insulation

412 The insulation in way of coal bunkers and of any surfaces exposed to excessive heat is to be of approved fire-resisting material. Where wood grounds are used for supporting insulation, asbestos strips are to be fitted between the wood grounds and the steel-work to which they are attached.

Where pipes carrying the refrigerating medium pass through bunkers the pipes may be packed with granulated cork but there is to be a thick outer covering of fire-resisting material and the whole is to be protected by steel plates which are to be sealed for airtightness.

Watertight Bulkhead Fittings

413 Where cooling pipes pass through watertight deck plating and bulkheads, the pipes are not to be in contact with the steelwork, and the fittings and packings of the glands are to be both fire-resisting and watertight (*see also* 405 and 408).

Airtightness of Insulation Lining and Air Ducts

414 Air ducts and insulation linings are to be so constructed and fitted that moving air is prevented from entering the insulation. Special care is necessary where cooling pipes, air refreshing ducts, fan supports, etc., protrude through the lining.

Cargo Battens

415 Cargo battens of about 2 inches × 2 inches and spaced approximately 15 inches apart are to be secured to the vertical surfaces of the chambers clear of air ducts, screens and cooler casings, and are to be fitted to suit the air flow. The outer edges of the battens are to be chamfered.

416 Cargo battens of not less than 3 inches × 3 inches are to be secured over the tunnel top insulation.

Stiffening of Insulation Linings and Air Ducts

417 Insulation linings and air screens on the sides of chambers are to be suitably stiffened to prevent crushing by cargo, in particular where ship sides are curved inwards and according to the nature of the cargo, whether general or refrigerated, which the Owners intend to carry in the chambers. Air duct sides or insulation linings which may have to support heavy loads are to be constructed to Owners' requirements.

Thermometers

418 Thermometers are to be of approved type, number and position in each chamber.

419 Thermometer tubes with their flanges and covers are to be insulated from the deck plating, and on weather decks they are to be so arranged that water will not run down the tubes when taking the temperatures.

420 The inside diameter of thermometer tubes is to be not less than 2 inches and the tubes are not to be in contact with cold decks.

421 Where thermometer tubes pass through compartments other than that which they serve, they are to be efficiently insulated.

Galvanizing of Fixtures

422 All steel bolts, nuts, hangers, brackets and fixtures which support or secure cooling appliances, insulation, meat rails, etc., are to be galvanized.

Section 5

TESTS AFTER COMPLETION

Thermometers

501 All thermometers provided for measuring chamber, air suction and air delivery temperatures are to be checked for accuracy by the contractors and a statement handed to the Surveyors. The Surveyors may use their discretion as to whether check tests are necessary.

Air Cooler Fan Outputs and Air Circulating Arrangements

502 Air cooler fans are to be tested by the contractors after the air circulating system has been completed and a statement of the results for each chamber handed to the Surveyors. The statement is to show the static pressure, the cubic feet of air circulated per minute, the fan speed and the power consumption. The air circulation arrangements in the chambers are to be checked for distribution.

Refrigeration Test

503 All plant is to be tested under working conditions.

Before the commencement of the test the Surveyors are to satisfy themselves that the electrical instruments, gauges and thermometers are accurate.

Where the minimum approved temperature required is the same in all chambers, or the difference is not greater than 5° F., the chambers are to be reduced in temperature simultaneously to not less than 2° F. below the lowest temperature required. As a minimum of 40° F. between the chamber and external temperatures is advisable it may be necessary to lower the chamber temperature further, but this should not be reduced below minus 20° F.

Where the temperature required in the separate chambers varies and the difference is greater than 5° F., each chamber is to be reduced in the manner described so that the normal temperature difference between the separate chambers is approximately maintained.

During the test the air cooler and air stirring fans are to operate at about maximum speed.

When the required temperatures have been attained, they are to be maintained constant by shutting down units and reducing the speed of the compressors remaining in continuous operation until the evaporating, condensing and brine (if used) temperatures and the speed of the compressor(s) are also steady, and this condition is to be maintained for a period of six hours, or longer if found necessary.

504 From the time the required temperatures have been attained, to the end of the test, all relevant temperatures and pressures are to be recorded at hourly intervals together with the speed and power consumption of the compressors and fan motors, and the power consumption of the brine and cooling water pumps.

505 Where an installation is to be completed and tested during a period when extremely low external temperatures are probable, and a reasonable difference between the chamber and external temperatures will not be possible without reducing the chamber temperatures below minus 20° F., or where the refrigerating machines are driven by constant speed motors, the case is to be submitted to the Committee for special consideration, and a test with the use of heaters may be required.

506 In cases where it is reasonable to believe that the refrigerating plant is inefficient an output test on the plant may also be required.

Air Cooler Defrosting Arrangements

507 The cooler defrosting arrangements are to be tested.

Section 6

SPARE GEAR

601 The following spare gear will be required in all cases:—

1 fan impeller of the propeller type of each size used.

1 set of the wearing parts of the crank shaft seals for each compressor where the crank case is subject to the refrigerant pressure.

1 set of crank shaft coupling bolts of each size used.

1 set of motor coupling bolts and washers, of each size used.

1 compressor piston with piston or connecting rod complete, of each size used.

1 complete assembly of each size of compressor suction and delivery valve.

1 complete set of packing for CO_2 compressor piston rod glands of each size used.

1 set of the working parts, together with packing and piston leathers, for the lubricating oil pump for CO_2 compressor rod glands.

1 gas regulator valve of each size used.

1 float regulator assembly of each size used.

1 set of suction and delivery valves for cooling water, air and brine pumps, of each size used.

1 set of driving belts of each size used.

Sundry lengths and bends of piping together with flanges, couplings and screwing appliances.

Sundry cocks, valves, flanges and fittings.

Assorted bolts, nuts, studs, packing and joint rings.

5 per cent. of the total number of electrical or tube thermometers, but not less than two of each.

Not less than two standard thermometers of the necessary temperature range.

1 spare battery for each electric thermometer indicator fitted.

1 hydrometer, where brine is the cooling medium.

1 halide lamp leak detector, where dichlorodifluoromethane or monochlorodifluoromethane is the refrigerant.

2 safety valve springs of each size used.

6 safety discs of each size used.

In cases where approval is given to alternative arrangements under N 104, additional spare gear may be required according to the circumstances of the case.

602 Where steam driven air circulating fans are fitted, the following spare gear will be required:—

For each size used:—

1 crank shaft.

1 steam piston and rod complete.

1 steam cylinder cover.

1 set of connecting rod top and bottom end bearing bushes, and bolts complete.

603 Where the refrigerating machines are direct driven by steam engines or by oil engines, the spare gear is to be in accordance with Chapter K.

604 Where any component of the refrigerating plant is electrically driven the spare gear is to be in accordance with M 2002, and in the case of fan motors, M 2004, except where a duplicate fan motor (*see* N 363) is installed ready for use.

605 It is assumed that the Owners will arrange for the necessary reserve supply of the refrigerant, calcium chloride and oils for the voyage intended.

Section 7

INSTALLATIONS NOT CONSTRUCTED UNDER SURVEY

701 When classification is desired for an installation not constructed under the supervision of the Society's Surveyors, application is to be made to the Committee in writing.

702 Full particulars and plans are to be forwarded for consideration, together with the particulars of the materials of the crankshafts, pressure vessels and pressure piping. The requirements of N 202 are to be used for guidance in regard to the information required.

703 A special examination is to be made at least to the extent required for Subsequent Special Surveys. (*See* N 860 to N 865.)

704 The thickness and material of the insulation, the particulars of the frames, beams, stiffeners and other steel work within the insulation, the air coolers and/or chamber grid piping, the compressors, evaporators and condensers are to be verified, and the particulars of the other components of the refrigerating plant are to be verified so far as practicable.

705 The installation is to conform with the requirements of N 3, N 4 and N 6, so far as applicable.

706 A test is to be carried out in accordance with N 503 to N 505, and air circulation arrangements in the chambers are to be checked for air distribution.

Section 8

PERIODICAL AND OTHER SURVEYS

Incidence of Surveys

801 For the retention of the class assigned installations are to be subjected to the periodical surveys specified in the following paragraphs.

802 Where desired by the Owners, the Intermediate and Running Surveys may be held at shorter intervals than those specified in 805 and 806, for a fresh record of Survey and the issue of a new Certificate.

803 A Loading Port Survey, as detailed in 814 to 818, is to be held at the loading port every voyage in the case of ships engaged on voyages of more than two months' duration, but where the voyages are of shorter duration, this survey need only be held at intervals of two months, provided the cargoes carried are of such a nature as not to damage the insulation or appliances in the insulated chambers nor to affect by taint or mould the refrigerated cargoes subsequently loaded.

804 A Biennial Survey as detailed in 819 to 843, is to be held, the first 2 years after the date of the survey for Classification, and thereafter two years from the date of the previous Biennial Survey.

805 An Intermediate Survey as detailed in 844 to 846 is to be held about twelve months after the date of the survey for Classification and about twelve months after each Biennial Survey.

806 Running Surveys as detailed in 847 to 851 may be held, if desired by the Owners, at intervals not exceeding twelve months in lieu of the Intermediate and Biennial Surveys.

807 A Special Survey as detailed in 852 to 865, is to be held at 4-yearly intervals, the first 4 years after the date of the survey for Classification, and thereafter four years from the date of the previous Special Survey. The requirements of 856 to 859 of this survey should be carried out

whenever possible at the time of the Special Surveys prescribed in B 8, except in the case of small installations where major parts of the ship's structure are not involved.

A Special Survey will normally become due at the same time as a Biennial or a Running Survey, but when they do not coincide and the other Periodical Surveys are held within the specified intervals the requirements of 853 to 859 and 861 to 865 only, of the Special Survey will be necessary, but the date assigned to the Special Survey will be that of the Biennial or the Running Survey.

When it is inconvenient for Owners to fulfil the Special Survey requirements at the due date, the Committee will be prepared to consider its postponement, either wholly or in part, for a period not exceeding twelve months from the due date, provided the other Periodical Surveys continue to be held at the specified intervals.

Survey of Repairs

808 Where any essential repairs and/or renewals are effected to an installation, these are to be carried out under the supervision, and to the satisfaction, of the Society's Surveyors. Repairs and renewals effected at ports where there is no Surveyor to this Society are to be surveyed by one of the Society's Surveyors at the earliest opportunity.

Alterations and Additions

809 Plans and particulars of any proposed alterations or additions to the refrigerated cargo chambers or refrigerating plant are to be submitted for approval, and the work is to be carried out under the supervision and to the satisfaction of the Society's Surveyors.

Record of Surveys

810 The date following the class notation Lloyd's RMC on the certificate indicates the date of the last Biennial Survey thus:— Lloyd's RMC 2,54, and the date under this notation indicates the date of the last Intermediate Survey thus :—Lloyd's RMC 2,54. These dates will be recorded in the appropriate columns of the Supplement to the Register Book.
12,54.

811 When Running Surveys are held in lieu of Biennial and Intermediate Surveys this will be indicated by the class notation Lloyd's RMC (RS) (with date). This date will be recorded in the appropriate column of the Supplement to the Register Book.

812 The date of the last Special Survey will be indicated by the notation SRMC (with date). This date will be recorded in the appropriate column in the Appendix to the Register Book and the Supplement.

Notice of Surveys

813 It is the responsibility of Owners to ensure that all surveys necessary for the maintenance of class are carried out at the proper time under the supervision of the Society's Surveyors.

It is, however, the normal practice of the Society to give timely notice to Owners when Periodical Surveys of Refrigerated Cargo Installations become due, but the non-receipt of such notice does not absolve Owners from this responsibility.

Loading Port Surveys

814 The chambers are to be examined in an empty state to ascertain that they are clean and free from odour which may adversely affect the cargo to be loaded, that the brine or other refrigerant pipe grids, cooler coils and connections are free from leakage, that the fixed cargo battens on the vertical surfaces are in good order, that cargo gratings or dunnage battens are provided for the floors or decks as required to suit the class of cargo, and that no damage has been sustained to the insulation or its lining prior to the loading of the refrigerated cargo. Any indications of defective insulation not considered to warrant immediate attention should be noted and specially reported.

815 The Surveyor is to satisfy himself that all scuppers and bilge suctions draining insulated spaces are in good working order, and that the liquid seals are primed.

816 The refrigerating installation is to be examined under working conditions, and the temperatures in the cargo chambers are to be noted.

817 If the ship loads at more than one port, one survey only at the first loading port will be required, provided it includes the examination of all the chambers which are to be used for refrigerated cargo during the voyage and general cargo is not subsequently carried in any of the chambers prior to loading the refrigerated cargo.

818 If there is no Surveyor to the Society available at the loading port(s), or if there is none obtainable from a port within a reasonable distance, the Committee will accept the report of a survey held at the loading port by a surveyor appointed by Lloyd's Agent; or in any case where there is no Lloyd's Agent, the report of a survey held by a reliable surveyor, if available; if no such surveyor is available, a report signed by two competent engineers of the ship will be accepted.

Biennial Surveys

819 Whenever possible the machinery in use is to be examined under working conditions on the ship's arrival at

the port of discharge before the refrigerated cargo is unloaded, irrespective of whether any further part of the survey is to be held at the port.

820 The entries in the ship's refrigeration logbook are to be examined in order to ascertain whether the performance of the installation has been satisfactory during the voyage. Breakdowns, irregularities in the working of the plant, or the too frequent or lengthy defrosting of air coolers, are to be noted and reported. This requirement may be carried out after the completion of the discharge before the examination of the cargo chambers.

When refrigerated cargo has not been carried during the voyage immediately prior to the survey the last records are to be examined.

821 Should the entries in the logbook show that the load on the plant is generally above the normal for the duty involved during the voyage, steps are to be taken to determine the cause and have it dealt with as found necessary.

822 The cargo chambers are to be examined for condition throughout, with the bilge and manhole plugs removed in the lower holds. Any indication of dampness or leakage into the insulation from tanks, piping within the insulation, scuppers, decks, hatchways or other sources, or of deterioration of attachments and supports of insulation and linings, air ducts, grids or meat rails, is to be investigated and any such defects rectified.

823 Where no air space is provided below the insulation on tank tops and there is no effective means of detecting leakages into the insulation, the floor covering is to be drilled and the insulation tested. Tank and tunnel top insulation in way of hatchways is to be similarly tested where dampness is evident.

824 Where chambers are cooled by forced air circulation and parts of insulation linings or air ducts are removed or repaired, care is to be taken that all joints are sealed to prevent air blowing into the insulation.

825 Air ducts, air cooler casings, insulation linings and protrusions through the linings are to be examined as far as practicable for condition, and special attention is to be given to the prevention of air blowing into the insulation. Where asphalt or similar material is used for floor covering, the junction with the insulation lining is to be examined for shrinkage which may cause air leakage into the insulation.

826 Where there is no evidence in the logbook of an abnormal load on the plant or on individual coolers or chamber grids, and there is no visible indication of insulation defects, the removal of parts of air ducts and insulation linings, and the drilling of linings is not required on vertical and overhead surfaces of chambers cooled by forced air circulation. The Surveyor should use his discretion as to whether the linings on these surfaces should be drilled in grid-cooled chambers having regard to the nature of the insulation and the material with which it is lined.

827 All test holes are to be effectively closed.

828 Hatch plugs and supports, chamber and access doors and their frames, air refreshing pipe and ventilator closing appliances, bilge and manhole plugs are to be examined for condition and airtightness. Thermometer tubes, their connections and fastenings are to be examined.

829 The bilges are to be cleaned; suction pipes, suction roses, sounding pipes and scupper non-return valves are to be examined. The Surveyor is to satisfy himself that all scuppers draining the chambers and air cooler trays are in good working order.

830 Cooling grids, air cooler coils, cooler trays and fans are to be examined. The Surveyor is to satisfy himself that sections of cooler coils or grids are not choked or partially choked.

831 Brine or water refrigerant pipe grids and cooler coils are to be tested to $1\frac{1}{2}$ times the working pressure or 40 lb. per square inch, whichever is the greater.

832 Primary refrigerant pipe grids and cooler coils with their valves and connections are to be examined whilst under the refrigerant pressure prevailing in the system at the time of the survey, with the plant at rest and the regulating valves opened sufficiently to obtain an approximate balance of pressure throughout the system.

833 The insulation of pipes carrying the refrigerating medium (service pipes, mains, leads and returns) between the chambers and the plant and/or control rooms is to be examined.

834 Where the refrigerating machinery or its auxiliaries are electrically driven a general examination of all the motors and their control gear and cables is to be made and the insulation resistance measured. The insulation resistance is to be not less than 100,000 ohms, and for the purpose of this test, each item may be taken separately. Where the Owners employ competent and reliable staff or an electrical contractor, the Surveyor may consult their records and, at his discretion, accept megger tests carried out by them.

Generating plant supplying electric power to the refrigerating machinery is to be examined generally, including the plant in operation. The ship's records of examination, overhaul and repair are to be sighted; if no records are available,

the ship's personnel are to be consulted in regard thereto. Any part of the plant is to be opened up for examination which the Surveyor may consider necessary. In the case of ships which are not classed with the Society, the Surveyor is also to ascertain that periodical examinations of the working parts continue to be held by the Classification Society concerned.

835 The primary refrigerant gas and liquid pipes, separators, receivers, driers, filters, condenser and evaporator coil terminals of the "coil in casing" type, and the shells of the "shell and tube" type, heat exchangers and all other pressure parts of the system are to be examined externally so far as practicable.

836 The refrigerating plant spare gear is to be examined.

837 The thermometers required by N 418 for measuring the chamber, air suction, and air delivery temperatures, are to be examined, and where repairs or renewals are found necessary, the thermometers concerned are afterwards to be tested for accuracy. Each thermometer is to be tested for accuracy at intervals not exceeding the period between Special Surveys; it is not necessary that all are tested at one time. The Surveyor may, at his discretion, accept the results of thermometer tests carried out by competent staff or by a contractor employed by the Owners. Records of tests for accuracy are to be available on board the ship.

NOTE.—In a number of ships, thermometers of a type not approved by the Society have been fitted in addition to those required by N 418; the former need not be examined or tested.

838 The water end covers of "shell and tube" type gas condensers are to be removed and the tubes and tube plates are to be examined.

839 All reciprocating refrigerating machines including those provided for primary refrigerant liquid cooling are to be opened up; the cylinders, valves and seats, crankshafts, connecting rods, pistons and piston rods, and all bearings are to be examined. The lower halves of main bearings need not necessarily be exposed if the Surveyor is satisfied with the alignment and wear. The lubricating arrangements are also to be examined.

840 Where the refrigerating machinery is driven by steam or internal combustion engines, all the working parts of the engines are to be opened up and examined, including all pumps directly driven by the driving engines, in a similar manner to that specified for the refrigerating machines (*see* 839).

Steam condensers exclusive to the refrigerating plant driving engines are also to be examined and, if considered necessary, they are to be tested.

841 The working parts of all independent gas condenser cooling and brine circulating pumps are to be examined. Where the standby condenser cooling pump is one of the pumps used for other purposes, this pump is also to be examined.

842 In the case of steam jet vacuum refrigerating plants, which provide the cooling medium circulated through the chamber cooling appliances, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, the condenser cooling, the condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

843 At intervals of 6 years from the date of construction, the steam pipes to steam engines driving refrigerating machinery and to steam jet vacuum refrigerating plants are to be examined and those pipes over 3 inches internal diameter are to be included in the survey required by C 9.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 9.

Intermediate Surveys

844 All the requirements of 819 to 837 (Biennial Survey) are to be complied with.

845 The water end covers of one of the "shell and tube" type gas condensers are to be removed and the tubes and tube plates are to be examined; if the Surveyor considers it necessary the other condensers of the same type are to be similarly treated.

846 The whole of the plant referred to in 839 to 842 is to be generally examined and any part is to be opened up for examination which the Surveyor may consider necessary. Any component opened up for overhaul at the time of the survey is also to be examined.

Running Surveys

847 All the requirements of 819 to 837 (Biennial Survey) and 845 to 846 (Intermediate Survey) are to be complied with.

848 The tubes and tube plates of each "shell and tube" type gas condenser are to be examined at intervals not exceeding two years.

849 The plant referred to in 839 to 842 (Biennial Survey) is to be opened up and examined in rotation so that the whole of the plant is examined within each period of two years, but one of the main refrigerating machines and, where applicable, its steam or internal combustion driving engine, one of the condenser cooling pumps and, where applicable, one of the brine circulating pumps, are to be examined either at each survey or within the previous six months.

In the case of steam jet vacuum refrigerating plants which provide the cooling medium circulated through the chamber cooling appliances, one of the flash chambers with its water spray arrangements, one of the thermo-compressor steam chambers and nozzles, one of the condenser cooling water pumps and one of the cooled water circulating pumps are to be examined either at each survey or within the previous six months.

850 *A survey book is to be kept on board the ship to show the date of examination of the various parts, and is to be signed by the Surveyor on the occasion of each survey.*

851 At intervals of six years from the date of construction the steam pipes to steam engines driving refrigerating machinery and to steam jet vacuum refrigerating plants are to be examined, and those pipes over 3 inches internal diameter are to be included in the survey required by C 9.

In the case of installations on unclassed ships, the Surveyors are to ascertain whether the steam pipes have been similarly dealt with by the Classification Society concerned, and if not, arrangements are to be made for the examination and tests in accordance with C 9.

First Special Survey

852 All the requirements of 819 to 843 (Biennial Survey) are to be complied with except where the surveys are being held in accordance with 806, when the requirements of 847 to 851 (Running Survey) are to be complied with.

853 Where the refrigerating machinery is driven by internal combustion engines and independent air compressors and air receivers exclusive to the refrigerating plant are installed, the working parts of the compressors and their intercoolers and safety devices are to be examined. The air receivers with their mountings, valves and safety devices are to be cleaned internally and examined internally and externally. If internal examination of the air receivers is not practicable, they are to be tested hydraulically to twice the working pressure.

854 The Surveyor is to satisfy himself that all pressure relief valves and/or safety discs throughout the refrigerating plant are in good order. No attempt, however, should be made to test primary refrigerant pressure relief valves on board ship.

855 In the case of steam jet vacuum refrigerating plants installed for sub-cooling the primary refrigerant liquid, the flash chambers and water spray arrangements, the thermo-compressor steam chambers and nozzles, the condensers, the cooled water circulating, condenser cooling and condensate extraction pumps, and the air pumps or ejectors are to be examined and, if considered necessary, the condensers are to be tested.

856 Sufficient insulation is to be stripped from pipes carrying the refrigerating medium at various points of the system particularly in bunkers or near boilers, on decks or where buried in hold insulation, to permit of the condition of the pipes being ascertained. Care is to be taken that on replacement the seal of the outer covering over the insulation is made good where the pipes are exposed to atmospheric conditions, particularly in bunkers, in accordance with N 412.

857 Sufficient air trunking and insulation lining is to be stripped from the chamber overhead and vertical surfaces to permit of the condition of the insulation, insulation linings, grounds, supports, hangers and fixtures which support the insulation, grids, meat rails, etc., being ascertained. Care is to be taken that on replacement the ducts and linings are sealed against air blowing into the insulation.

858 Sufficient tank top insulation is to be stripped to permit of the condition of the grounds and inner insulation lining being ascertained.

859 Sea connections to condenser cooling water pumps are to be opened up and examined.

Subsequent Special Surveys

860 All the requirements of 852 to 859 (First Special Survey) are to be complied with.

861 The coils of gas condensers and evaporators (brine coolers) of the "coil-in-casing" type are to be drawn for examination where this is reasonably practicable. In the case of condensers and evaporators which are unwieldy or where there is insufficient head room, an examination of the coils is to be made in place, through the openings in the casings.

The coils of the condensers are to be tested to a pressure of 250 lb. per square inch for dichlorodifluoromethane systems, 1,000 lb. per square inch for ammonia and monochlorodifluoromethane systems and 2,000 lb. per square inch for carbon dioxide systems.

The coils of the evaporators are to be tested to a pressure of 200 lb. per square inch for dichlorodifluoromethane systems, 500 lb. per square inch for ammonia and monochlorodifluoromethane systems and 1,500 lb. per square inch for carbon dioxide systems.

862 Gas condensers of the "shell and tube" type are to have the water or brine end covers removed and are to be tested to a pressure of 250 lb. per square inch for dichlorodifluoromethane systems, and 400 lb. per square inch for ammonia and monochlorodifluoromethane systems.

Gas evaporators (brine coolers) of the "shell and tube" type are to have the brine end covers removed and are to be tested to a pressure of 200 lb. per square inch for dichlorodifluoromethane systems and 300 lb. per square inch for ammonia and monochlorodifluoromethane systems.

863 Primary refrigerant liquid sub-cooling coils in flash chambers of steam jet vacuum refrigerating plants are to be examined and tested to the same pressure as that required for condensers in 861.

864 Where brine or water is used for sub-cooling the primary refrigerant liquid in heat exchangers of the "shell and tube" type, the heat exchangers are to be examined and tested in the same manner as that required for condensers in 862.

"Double pipe" type heat exchangers are to be examined so far as practicable with the gas piping under the same pressures as that required for condensers in 862 and the water or brine from the outlets is to be tested for gas leakage.

Other types of heat exchangers using brine or water are to be examined and tested at the discretion of the Surveyor according to the design of such equipment.

865 Primary refrigerant chamber grids or air cooler coils are to be tested in place to a pressure of 100 lb. per square inch for dichlorodifluoromethane, 150 lb. per square inch for ammonia or monochlorodifluoromethane systems, and 1,000 lb. per square inch for carbon dioxide systems.

Section 9

PORTABLE REFRIGERATED CARGO CONTAINERS

General

901 Portable refrigerated cargo containers intended to be carried on the Owners' ships, and loaded and discharged on board, which comply with N 1 to N 8, in so far as they are applicable, except as provided in the following paragraphs will be included in the installations covered by B 901 and B 902.

902 The Shipowners' name and an identification number are to be clearly marked on each container. It is also to be indicated on the container that it is not to be lifted in a loaded condition.

903 A log book showing the particulars of the refrigeration of the container during each voyage is to be maintained, and this is to be made available to the Surveyor at each of the surveys required by 917.

Where the plant is operated by thermostatic control the intervals during which the machinery is working and at rest should be recorded occasionally, particularly during the period of maximum external temperature conditions of each voyage.

Class Notation

904 The class notation will be in accordance with N 1 except that where the refrigerant condenser is air cooled the class notation shown in N 101 will give the maximum ambient temperature instead of the maximum sea temperature, e.g., "to maintain temp. 10° F. with ambient temp. 104° F. maximum".

Where the refrigerating machinery is electrically driven and dependent on the ship's generators for power, the class assigned will be subject to suitable electric power being available at all times when the container is loaded with refrigerated cargo.

Special Survey during Construction

905 The requirements of N 2 are to be complied with in so far as they are applicable.

Refrigerating Plant

906 The requirements of N 3 are to be complied with in so far as they are applicable, except as modified by 907 to 909.

907 Where the refrigerant condenser is air cooled and the maximum gas discharge pressure is above the maxima specified in N 326 and N 330, the design pressure is to be correspondingly increased.

908 Where the design pressure is increased in accordance with 907, the test pressures specified in N 339 are to be increased proportionately.

909 Where "shell and tube" type evaporators (brine coolers) and condensers can be readily removed, the space for the withdrawal and renewal of tubes in accordance with N 348 will not be required.

Cargo Space

910 The external structure, including the door, is to be of robust design and constructed of, or covered with, water vapour resisting materials, and the joints are to be effectively sealed. The structure is to be carefully examined for tightness before the insulation is applied. The access door is to be airtight when closed.

911 The containers are to comply with the requirements of N 404 and N 405, N 407 and N 408, N 414 and N 415, N 417 and N 422 in so far as they are applicable.

912 Drains of not less than $\frac{3}{4}$ inch bore are to be provided from the cargo space and air cooler trays, and the drains are to be fitted with means of closure operable from outside the cargo space.

913 Thermometers are to be of approved type and position in the cargo space. Where thermometer tubes are provided the method of attachment is also to be approved.

Tests after Completion

914 The requirements of N 5 are to be complied with in so far as they are applicable.

Spare Gear

915 The spare gear is to be in accordance with N 6 in so far as that Section is applicable.

Containers not Constructed under Survey

916 The requirements of N 7 are to be complied with in so far as they are applicable, except as amended by this Section.

Periodical and other Surveys

917 For the retention of the class assigned periodical and other Surveys are to be carried out in accordance with N 8 except as modified in the following paragraphs.

Loading Port Surveys

918 The requirements of N 814 and N 816 are to be complied with and, in addition, the Surveyor is to satisfy himself that the container is placed on board in such a position as to provide free access to the container by the ship's personnel for servicing the refrigerating plant and noting the temperatures; and, where the refrigerant condenser is air cooled, to allow free flow of fresh air to, and heated air from, the condenser.

919 Generating plant supplying power and the cables and connections to the refrigerating machinery are to be examined generally.

920 The Surveyor is also to satisfy himself that the drains from the cargo space and air cooler trays are clear and the closing devices are in order.

Biennial Surveys

921 All the requirements of N 819 to N 828, and N 830 to N 841, except the second paragraph of N 834, are to be complied with in so far as they are applicable.

922 The cargo space and air cooler tray drains and their closing devices are to be examined.

Intermediate Surveys

923 All the requirements of N 819 to N 828 and N 830 to N 837, except the second paragraph of N 834, and those of N 845 and N 846, and 922 are to be complied with in so far as they are applicable.

Running Surveys

924 All the requirements of N 819 to N 828 and N 830 to N 837, except the second paragraph of N 834, and those of N 845 and N 846, N 848 to N 850, and 922 are to be complied with in so far as they are applicable.

925 Where one refrigerating unit only is installed the Running Survey system cannot be adopted.

First Special Survey

926 All the requirements of N 853 to N 857 in so far as they are applicable and, in addition, those of 921 and 922 (Biennial Surveys) or, where the surveys are being held in accordance with N 806, those of 924 (Running Surveys), are to be complied with.

927 Sufficient covering and insulation is to be stripped from the floor of the container to permit of the condition of the insulation, grounds and structure being ascertained.

Subsequent Special Surveys

928 All the requirements of N 861 to N 865, in so far as they are applicable, and, in addition, those of 926 and 927 are to be complied with.

20th July, 1961

Chapter P

QUALITY AND TESTING OF MATERIALS

Note:—For list of steel manufacturers see Appendix to this Chapter.

Section 1

SHIP, BOILER AND MACHINERY STEEL GENERAL REQUIREMENTS

Approval of Works and Method of Manufacture

101 The steel shall be manufactured at works approved by the Committee, by the open hearth or electric furnace process, or by other process specially approved by the Committee.

Testing and Inspection

102 The prescribed tests and inspection shall be carried out at the place of manufacture before despatch, but in the event of any material proving unsatisfactory during working or fabrication, such material shall be rejected notwithstanding any previous certificates, and the Surveyor may require further tests from other materials from the same batch.

All the test pieces are to be selected and stamped by the Surveyor or an authorised deputy and tested in his presence.

Surface Inspection and Dimensions

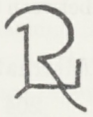
103 Surface inspection and verification of dimensions are the responsibility of the steelmaker, and acceptance by the Surveyors of material later found to be defective shall not absolve the steelmaker from this responsibility.

Identification of Materials

104 The steelmaker shall adopt a system for the identification of ingots, slabs and finished pieces which will enable the material to be traced to its original heat, and the Surveyors shall be given full facilities for so tracing the material when required.

Branding

105 Every finished piece (*see* P 212) is to be clearly marked by the makers in at least one place with the Society's brand and the following particulars:—



(i) Agreed identification mark for the grade of steel.
(ii) Name or initials to identify the steelworks.
(iii) Number and/or initials to identify the heat.
(iv) Purchaser's identification mark if required by the purchaser.

Where a number of light materials are securely fastened together in bundles, the manufacturer may, subject to the agreement of the Surveyors, brand only the top piece of each bundle, or alternatively, a firmly fastened durable label containing the brand may be attached to each bundle.

Defacing of Rejected Material

106 In the event of any material, bearing the Society's brand, failing to comply with the test requirements, the brand is to be unmistakably defaced.

Mill Sheets

107 The Surveyor shall be supplied with at least two copies of the mill sheets or shipping statements of all accepted material which documents should be separate for each grade of steel. The documents shall contain, in addition to the description, dimensions, etc., of the material, the following particulars:—

(i) Purchaser's identification marks.
(ii) Identification of the heat.
(iii) Identification of the steelworks.
(iv) Identification of the grade of steel.
(v) Ladle analysis (elements controlled by the specification only).
(vi) Order or ship number for which intended.
(vii) If the ship steel is of rimming quality, this should be stated.

Maker's Certificate

108 Before the mill sheets or shipping statements are signed by the Surveyor, the manufacturer is required to furnish him with a certificate stating that the material has been made by an approved process and that it has been subjected to and has withstood satisfactorily the required tests in the presence of the Surveyor or his authorised deputy. The following form of certificate will be accepted if stamped or printed on each mill sheet with the name of the steelworks and initialled for the makers by an authorised official:—

> "We hereby certify that the material herein described has been made by the.....process (process to be stated) approved by and in accordance with the Rules of Lloyd's Register of Shipping for Grade.....steel, and is that which has been tested in the presence of the Society's representative with satisfactory results".

Facilities for Inspection

109 The manufacturers shall afford the Surveyors all necessary facilities and access to all relevant parts of the works to enable them to verify that the approved process is adhered to, and for witnessing the selection and testing as required by the Rules, and for verifying the accuracy of the testing equipment.

Steel not Produced where Rolled

110 When steel is not produced at the Works at which it is rolled, a certificate shall be supplied to the Surveyor at the rolling mill stating the process by which it was manufactured, the name of the manufacturer who supplied it, the number of the heat from which it was made and the ladle analysis. The Surveyors shall have access to the works at which the steel was produced.

Tensile Test

111 The tensile tests shall be carried out by competent personnel in an approved machine of adequate capacity. The machine shall be maintained in satisfactory and accurate condition and shall be rechecked and calibrated, preferably in the presence of the Surveyors, at suitable intervals agreed by the Society. A record of such rechecking and calibrations shall be kept available in the test house. The test pieces should be cut with their axes perpendicular to the final direction of rolling except in the case of sections and narrow flats. The tensile strength is defined as the maximum load divided by the original cross-sectional area of the tensile test piece.

Section 2

STEEL FOR HULL STRUCTURES

NOTE.—*These requirements are primarily intended to apply to steel not exceeding 2 inches in thickness. For greater thicknesses, certain variations in the requirements may be allowed or required in particular cases after consideration of the technical circumstances involved.*

Freedom from Defects

201 (*a*) The steel is to be reasonably free from segregations, surface flaws and non-metallic inclusions. The finished material is to be free from cracks and lamination. It shall also have a workmanlike finish and must not have been hammer dressed.

(*b*) Surface defects may be removed by grinding provided that the thickness is in no place reduced to less than 93 per cent of the nominal thickness but in no case by more than $\frac{1}{8}$ inch. The extent of such repairs shall be agreed in each case with the Surveyors, and the repairs shall be carried out under the Surveyors' supervision unless otherwise agreed.

(*c*) Surface defects which cannot be dealt with as above may be repaired by chipping or grinding followed by welding, subject to the Surveyors' consent and under their supervision provided:—

(i) that after removal of the defect, and before welding, the thickness of the piece is in no place reduced by more than 20 per cent (for definition of "piece" *see* 212).

(ii) that the welding is carried out by an approved procedure, by competent operators with approved electrodes, and that the welding is ground smooth to the correct nominal thickness.

(iii) that subsequent to the finish grinding, the piece may be required to be normalised or otherwise heat treated at the Surveyors' discretion. Re-normalising will always be required if the piece has been normalised before the repair.

Distinguishing Marks

202 The entire marking (*see* P 105) is to be surrounded by a clear mark in paint of the following distinctive colours:—

Grade A steel	...	...	white
Grade B steel	...	...	green
Grade C steel	...	...	blue
Grade D steel	...	...	red
Grade E steel	...	...	yellow

Standard Tensile Test Piece

203 This test piece shall have a rectangular cross-section with thickness equal to that of the material from which it is cut and a width of 1 inch with a length between gauge marks of 8 inches. The parallel length shall not be less than 9 inches. The ends of the test piece may be increased in width to suit the grips of the machine, the transition between the different widths being made with a gentle curve.

Alternative Tensile Test Pieces

204 Tensile test pieces of other dimensions or of cylindrical form may be used, provided that the elongations comply with 205, and provided that the cross-sectional area is not less than $\frac{1}{4}$ square inch.

Elongations in Tensile Test

205 (*a*) The required minimum elongations, E, are indicated in the appropriate Rules for each grade of steel.

(For ship steel *see* Table II.) These elongations are based on test pieces having gauge lengths equal to 5·65 times the square root of the cross-sectional area, or 5 times the diameter.

(*b*) For test pieces having gauge lengths bearing other relationships to the cross-sectional area, the equivalent elongations shall be calculated from the following formula:—

$$n = 2E\left(\frac{\sqrt{A}}{L}\right)^{0\cdot40}$$

where n is the equivalent minimum elongation,

A is the actual cross-sectional area of the test piece,

L is the actual gauge length,

E is the specified minimum percentage elongation for test pieces in which

$L = 5\cdot65\sqrt{A}$ (*see* 205 (*a*)).

NOTE.—A *and* L *may be in any consistent units.*

(*c*) For the "standard" test piece (*see* 203) the minimum percentage elongations shall not be less than the following:—

Thickness	*Minimum Elongation*
$\frac{1}{4}$ inch	0·68E
1·2 inches and over	0·95E

where E is the specified minimum as per 205 (*a*) above. The elongations for thicknesses between $\frac{1}{4}$ inch and 1·2 inches may be obtained from the above by linear interpolation.

Bend Tests

206 The bend test shall consist in bending a strip or bar of the material until the ends are parallel to each other, and at a distance apart not exceeding three times the thickness or diameter of the strip or bar.

The strips shall have a width at least equal to the thickness but not less than 1 inch and a thickness not less than that of the material tested, retaining the original rolled surfaces. The sharp edges of the strip may be removed by filing or machining, to a radius not exceeding $\frac{1}{10}$ of the thickness of the strip.

When the power of the available testing machine is insufficient to bend a test piece of the full thickness, this latter may be reduced by machining from one face or by turning down a round bar provided that the final thickness or diameter is not less than 1 inch. Strips shall be so bent that the original rolled surface is on the tension side.

The strips shall be cut with their lengths perpendicular to the direction of rolling except in the case of sections and narrow flats. The bending may be performed by pressure or by blows.

The bend test will be considered successful if no cracks or laminations appear.

Impact Tests

207 The impact test pieces (where specified) shall be of the Charpy V-notch type, 10 mm. square in cross-section, 55 mm. long, and having in the centre of the length of one face a perpendicular V-notch with an included angle of 45°, a depth of 2 mm. and a root radius of 0·25 mm. The specimens are to be accurately machined to the tolerances given in Table I and to a good finish. The prescribed dimensions are to be carefully and systematically checked. The test pieces shall be cut with their longitudinal axes parallel to the final direction of rolling of the material. The notch shall be cut in a face of the test piece which was originally perpendicular to the rolled surface.

TABLE I

DIMENSIONS AND TOLERANCES FOR CHARPY V-NOTCH TEST PIECES

Dimensions	Nominal Dimension	Tolerance
Length	55 mm.	±0·60 mm.
Width	10 mm.	±0·11 mm.
Thickness	10 mm.	±0·11 mm.
Angle of notch	45°	±2°
Depth below notch ...	8 mm.	±0·11 mm.
Root radius	0·25mm.	±0·025 mm.
Distance of notch from end of test piece	27·5 mm.	±0·42 mm.
Angle between plane of symmetry of notch and longitudinal axis of test piece	90°	±2°

The position of the notch shall not be nearer than 1 inch to a flame-cut or sheared edge.

In the case of sections, the test pieces are to be cut from the thickest part.

The tests are to be carried out with the test pieces at a temperature carefully controlled to within ±1° C. of the required temperature, on a Charpy impact machine of approved type installed in an approved manner having a

gap of 40 mm., a striking velocity between 4·5 and 6 metres per second, and a striking energy of not less than 15 kilogramme metres. The angle of the striking edge of the pendulum is to be 30° with the edge rounded to a radius not exceeding 2 mm. The machine is to be periodically checked and calibrated on the lines indicated in paragraph P 111.

Alternative Types of Test

208 Other alternative types of test may be substituted for the Charpy V-notch impact test provided that equivalent standards of notch ductility can be established to the satisfaction of the Society.

Number of Tensile Tests

209 For each batch presented, one tensile test shall be made from one piece rolled from each cast unless the weight of finished material is greater than 40 tons in which case one extra test shall be made from each 40 tons or fraction thereof. Additional tests are to be made for every variation of 0·20 inches in the thicknesses of pieces from the same cast.

Number of Bend Tests

210 One bend test is to be made from each piece rolled, except that one bend test only need be made from every two pieces having a finished weight of less than 2 tons each, provided they are from the same cast.

Number of Impact Tests (where required)

211 Unless otherwise specified for a particular grade of steel, at least one piece is to be selected for impact testing from the thickest batch from each cast, unless the weight of finished material rolled from the cast is greater than 40 tons in which case one extra test will be made from a different piece from each 40 tons or fraction thereof, provided that the same procedures have been used in manufacture.

When plates of different widths are included in batches of the same thickness the widest plate is to be preferred for testing.

From each piece so selected, three impact tests as described in 207 shall be carried out. The average values obtained from these tests shall comply with the requirements. If, however, the average obtained fails to comply by an amount not exceeding 15 per cent of the required value, three additional test pieces from the same sample may be tested, and the results added to those previously obtained to form a new average, which must comply with the requirements.

Definition of "Piece"

212 The term "piece" is to be understood to mean the rolled product from a single slab, or from a single ingot if this is rolled directly into a plate, bar or section. The term "test piece" where it occurs means the sample of material which is actually tested.

Additional Tests before Rejection

213 (*a*) When the tensile or bend tests on the first piece selected in accordance with 209 and 210 fail to meet the requirements, two further tests of the same kind may be made from the same piece. If both these additional tests are satisfactory the piece and the remaining pieces from the same cast may be accepted.

(*b*) If the additional tests referred to in (*a*) are unsatisfactory the piece is to be rejected, but the remaining material from the same cast may be accepted provided that two of the remaining pieces selected in the same way are tested with satisfactory results.

(*c*) If the impact tests, carried out in accordance with 211 on the first piece selected, fail to meet the requirements the piece is to be rejected, but the remaining material from the same cast may be accepted provided that two of the remaining pieces, selected in the same way, are tested in the same way with satisfactory results.

(*d*) If any test piece fails because of faulty preparation or (in the case of a tensile test) because of fracturing outside the middle half of the gauge length, the defective test piece may at the Surveyor's discretion be discarded and replaced by an additional test piece from the same piece.

(*e*) At the option of the steelmakers, rejected material may be re-submitted after heat treatment or re-heat treatment or may be re-submitted as another grade of steel, and may then be accepted provided that the required tests are satisfactory.

Position of Samples for Testing

214 Except where otherwise specially agreed, the samples taken from the rolled material for the preparation of test pieces are to be cut from the end of the piece corresponding to the top end of the ingot. When the axis of the ingot is transverse to the length of the piece, either end may be selected but the sample should preferably be taken near to the edge corresponding to the top of the ingot.

Heat Treatment

215 Unless otherwise specified, or required by the conditions of approval of the process, the material may be presented in the "as rolled" or heat treated condition at the maker's option, subject to full compliance with the remainder of these Rules, and provided that the material

TABLE II

GRADE	A	B	C	D	E
1. METHOD OF MANUFACTURE	As P 101	As P 101	Process to be specially approved	Process to be specially approved	Process to be specially approved
2. DEOXIDATION	Killed or semi-killed (*See* Note 1)	Killed or semi-killed	Fully killed, fine grain practice (Aluminium treated)	Any method except rimmed steel	Fully killed, fine grain practice (Aluminium treated)
3. AUSTENITIC GRAIN SIZE (McQuaid-Ehn method) ASTM scale (*See* P 217)	—	—	5 or finer To be determined on each charge (*see* Note 4)	—	5 or finer To be determined on each charge
4. CHEMICAL COMPOSITION (ladle analysis)					
Carbon	*See* Note 2	0·21% max.	0·23% max. } Note	0·21% max. } Note	0·18% max. } Note
Manganese ...	*See* Note 2	0·80% min. } *See* Notes 3 & 5	0·60% to 1·40% } 5	0·60% to 1·40% } 5	0·70% to 1·50% } 5
Silicon	—	—	0·15% to 0·30%	0·35% max.	0·10% to 0·35%
Sulphur	0·05% max.	0·05% max.	0·05% max.	0·05% max.	0·05% max.
Phosphorus ...	0·05% max.	0·05% max.	0·05% max.	0·05% max.	0·05% max.
5. TENSILE TEST					
Tensile strength, t/sq. in. ... ... (*See* P 111)	26 to 32	26 to 32	26 to 32	26 to 32	26 to 32
Elongation E.% on $L=5{\cdot}65\sqrt{A}$ ... (*See* P 205)	22%	22%	22%	22%	22%
6. IMPACT TEST					
Temperature ...	—	—	—	0° C.	—10° C.
Energy	—	—	—	35 ft. lb. min. or 4·84 kgm. min.	45 ft. lb. min. or 6·22 kgm. min. Every plate to be tested
7. BEND TEST	As P 206	As P 206	As P 206	As P 206	As P 206
8. HEAT TREATMENT	*See* P 215	*See* P 215	Normalised over $1\frac{1}{4}$ in. (33 mm.) thick	*See* P 215	Normalised

NOTES.—TABLE II

1. For Grade A, rimming steel may be accepted subject to limitations by special agreement with the Society.

2. For Grade A in thicknesses over $\frac{1}{2}$ inch the manganese content shall not be less than 2·5 times the carbon content.

3. For Grade B, when the silicon content is 0·15 per cent or more (killed steel) the minimum manganese content may be reduced to 0·60 per cent.

4. For Grade C the determination of grain size may be alternatively substituted by impact tests as required for Grade D.

5. For Grades B, C, D and E, the sum of carbon content plus $\frac{1}{6}$ of the manganese content shall not exceed 0·40 per cent.

6. For use of Grade C in lieu of Grade D (*see* D 103).

which is presented in the normalised or otherwise heat treated condition is to be tested separately from material presented in the "as rolled" condition, even when all such material is from the same cast.

The sample of material from which test pieces are cut must be heat treated together with and in the same way as the material presented. Test specimens may not be separately heat treated in any way.

Chemical Analysis

216 The chemical composition shall be determined by the makers in an adequately equipped and competently staffed laboratory on samples taken from each ladle of each cast. The maker's analysis will be accepted subject to occasional checks if required by the Surveyors.

Austenitic Grain Size

217 The austenitic grain size where required is to be determined by the McQuaid-Ehn method from samples taken from each ladle of each cast. The grain size numbers indicated refer to the ASTM scale described in ASTM E112-58T, or any later ASTM specification which may supersede it.

Section 3

STEEL FOR BOILERS, PRESSURE VESSELS AND WELDED MACHINERY STRUCTURES

General

301 Plates, sections and bars intended for marine boilers, pressure vessels and welded machinery structures are to comply with the requirements and tests of this section. The requirements are not applicable to pressure vessels containing radio-active materials or gases.

Orders for Materials

302 The order should specify the required type, grade and condition of the material, and the purpose for which it is intended.

Process of Manufacture

303 The steel is to be made at an Approved Works by the open hearth, electric furnace or other approved process. The melting shop practice is to be such as to minimise the included non-metallic contents of the steels. Ingots are to be cast in chilled moulds.

Carbon and carbon-manganese steels are to be killed or semi-killed. Rimmed steels are not acceptable.

Sufficient discard is to be made from the top and bottom of each ingot to ensure soundness in the portion used for plates, bars and sections. Periodically and at the Surveyor's discretion sulphur prints or other suitable proving tests may be required from the rolled material to demonstrate that this has been fulfilled.

The size of ingot is to be proportioned to the thickness of the plate, section or bar in order that the amount of rolling work is adequate to ensure a satisfactory steel structure in the finished product.

Freedom from Defects

304 The steel is to be free from harmful segregations, flaws and laminations. It is to have a workmanlike finish and must not have been hammer dressed. Material despatched from the steel works must not have been repaired by welding.

Slight scale or shell may be removed by careful chipping, filing, grinding, or sand- or shot-blasting. Such rectification must be completed to the satisfaction of the Surveyor.

STEEL PLATES

Carbon and Carbon-Manganese Steel Plates

305 Provision is made for carbon and carbon-manganese steel plates of thicknesses up to 6 inches and having tensile strengths ranging from 24 to 38 tons/in.^{2} For purposes of constructional applications and test requirements the steels are graded according to tensile strength as listed in Table I.

TABLE I

MECHANICAL PROPERTIES OF PLATES, SECTIONS AND BARS

Material—Carbon and Carbon-Manganese Steels

Grade	Tensile Strength Tons/in.^{2}		Minimum Percentage Elongation on Gauge Length			Bend Test Max. Radius of Former
	Min.	Max.	8 ins.	$4\sqrt{A}$	$5{\cdot}65\sqrt{A}$	
1	24	28	25*	30	26	1 t
2	26	30†	23*	29	25	1 t
3	28	32†	20*	27	23	$1\frac{1}{2}$t
4	30	34†	18*	24	21	$1\frac{1}{2}$t
5	32	38	17*	22	19	$1\frac{3}{4}$t

* For plates under $\frac{3}{8}$ inch in thickness the minimum percentage elongation values may be reduced by 3.

† For individual plates exceeding 10 tons in weight the maximum tensile strength may be increased by 2 tons/in.^{2}

A is the area of the cross-section of the test piece.

t is the thickness or diameter of the test piece.

NOTE.—When these steels are used for welded constructions, attention should be given to J 2203 and J 2214. These requirements are particularly important for Grades 4 and 5 steels.

Chemical Composition of Carbon Steels

306 (*a*) Ladle analyses of carbon steels are to comply with the following ranges of chemical composition:—

Carbon	0·23% max. * for Steels of Grades 1 and 2
	0·26% „ † „ „ „ Grade 3
	0·30% „ ‡ „ „ „ Grades 4 and 5
Silicon	0·15% to 0·35% (applicable to killed steels only)
Manganese	0·50% to 1·00%
Sulphur	0·050% max.
Phosphorus	0·050% max.

* For plates over 3 inches thick the carbon content may be increased to 0·25% max.

† For plates over 3 inches thick the carbon content may be increased to 0·28% max.

‡ For plates over 3 inches thick the carbon content may be increased to 0·32% max.

Residual elements are to be maintained as low as possible and should not exceed the following:—

Copper	0·30%
Nickel	0·30%
Chromium	0·25%
Molybdenum ...	0·10%
Total Residuals ...	0·70%

Chemical Composition of Carbon-Manganese Steels

(*b*) Ladle analyses of carbon-manganese steels are to comply with the following range of composition:—

Carbon	0·20% max.
Manganese ...	1·60% max.
Silicon	0·15% to 0·50% (for killed steels only)
Sulphur	0·050% max.
Phosphorus ...	0·050% max.

The residual elements are to comply with the limitations given in 306(a) for the composition of carbon steels.

In addition to the above, for carbon-manganese steels the sum of the carbon percentage and one sixth of the manganese percentage is not to exceed:—

0·40 for Steels of Grades 1 and 2
0·42 for Steels of Grade 3
0·44 for Steels of Grades 4 and 5

Low Alloy Steel Plates

(*c*) Where it is proposed to use low alloy steels, particulars of the manufacture, chemical composition, mechanical properties and heat treatment are to be submitted for approval. For high temperature applications typical long-term creep and rupture data, scaling and corrosion resistance at the operating temperatures are to be submitted if required. These steels will be tested and accepted on the basis of the approved specification and such other tests as may be considered necessary.

Statement of Analysis

(*d*) The steelmaker is to provide a statement giving the ladle analysis of the steel for each plate. For a carbon or a carbon-manganese steel this should include the carbon, manganese, silicon, sulphur and phosphorus contents. For low alloy steels the analysis should also include the principal alloying elements.

Residual elements need not be stated in all cases but these may be required for periodical check by the Surveyor in attendance at the steelworks.

Steels for Boilers and other Pressure Vessels

307 The grades of carbon and carbon-manganese steel plates are restricted to the applications in boiler and pressure vessel constructions as listed in Table II.

TABLE II

Application	Grade of Steel
Welded Pressure Vessels Class 1 ...	1 2 3 4 5
„ „ „ „ 2A, 2B and 3	1 2 3
Shells of all-riveted boilers	2 3 4
Shells of riveted boilers with welded compensating rings and attachments	2 3
Boiler furnaces, combustion chambers and flanged plates	2
Forge welded pressure vessels ...	1 2

Killed steel is to be used for Class 1 fusion welded and Class 1 forge welded pressure vessels.

Silicon killed steel is to be used for pressure vessels where the operating metal temperatures exceed 750° F.

Steel intended for pressure vessels operating at low metal temperatures should be fine grained and may be aluminium killed; proposed applications are to be submitted for approval.

Steels for Welded Engine Structures

308 Grades 1 and 2 carbon and carbon-manganese semi-killed steels are suitable for welded engine bedplates and similar engine structures and are acceptable as meeting the requirements of H 903.

Heat Treatment of Plates

309 Grades 1, 2 and 3 carbon and carbon-manganese steel plates exceeding $1\frac{3}{4}$ inches thickness and all thicknesses of Grades 4 and 5 plates are to be normalised. The steelmaker is to provide a statement giving the heat treatment condition of each plate.

Hot Spun, Bent or Pressed Plates

310 When plates are hot formed in the production of cylindrical shells and dished ends for boilers and other pressure vessels, the fabricator must either demonstrate that the process is so controlled as to ensure that the finished steel has a normalised structure or normalise the parts on completion of the operation.

For low alloy steels and Grades 4 and 5 carbon and carbon-manganese steels check tensile tests are required from each hot formed (and where applicable heat treated) cylindrical shell and dished end. Test pieces are to be selected from material which is to be discarded from the hot formed part. Providing the Surveyor's consent is obtained, a curved test plate may be cold flattened to obtain a suitable test piece.

Alternative procedures to the above may be submitted for special consideration.

Number of Tests—Plates

311 At least one set of mechanical tests comprising a tensile and a bend test is to be made on the material of each plate as rolled. One set of test pieces is to be selected from the material at the quarter-width of each plate weighing less than $2\frac{1}{2}$ tons. For each heavier plate, one set of test pieces is required from the quarter-width of both ends, except where the material will be used for the fabrication of welded engine structures, when only one set of tests is required. The test pieces are to be cut transverse to the principal direction of rolling.

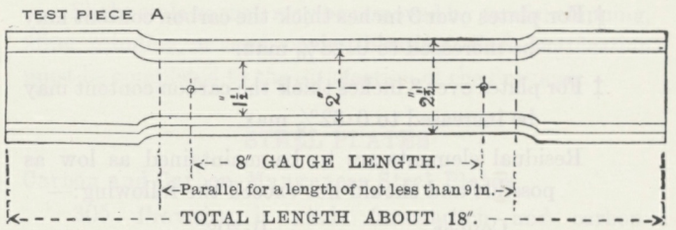
Where plates are normalised at the steelworks the test material is not to be removed from a plate until the heat treatment is completed.

If specified by a manufacturer of fusion welded boilers or pressure vessels, test material cut from plates may be stress relief heat treated before machining the test pieces. This heat treatment is to be in accordance with J 1925.

NOTE.—Although this procedure may provide for some loss of tensile strength of the plates due to stress relief heat treatment, final acceptance is based on the actual tensile strength of the cross weld tensile test piece detailed in J 1920.

Tensile Test Pieces for Plates

312 Wherever practicable the rolled surfaces are to be retained on two opposite sides of the test piece. When the elongation is measured on a standard test piece having a gauge length of 8 inches, for material more than ·875 inch in thickness the width of the test piece between the gauge points is not to exceed $1\frac{1}{2}$ inches; for material ·875 inch to ·375 inch in thickness, inclusive, the width is not to exceed 2 inches; for material less than ·375 inch in thickness the width is not to exceed $2\frac{1}{2}$ inches. In other respects the test pieces are to conform generally to the standard test piece A.



For Thicknesses over ·875":—Maximum width allowed=$1\frac{1}{2}$".

For Thicknesses ·375" to ·875":—Maximum width allowed=2".

For Thicknesses under ·375":—Maximum width allowed=$2\frac{1}{2}$".

Any straightening of the test pieces which may be required is to be done cold. For plates over $1\frac{1}{2}$ inches in thickness a round proportional tensile test piece may be used as an alternative provided the cross-sectional area is not less than 0·5 square inch. (See also 305, Table I).

For check tensile tests on parts hot formed from plates, any suitable standard test piece is acceptable providing the cross-sectional area is not less than 0·25 square inch.

Bend Test Pieces for Plates

313 Bend test pieces if practicable are to be of full plate thickness and not less than $1\frac{1}{2}$ inches in width. For thick plates two bend test pieces, $1\frac{1}{2}$ inches wide by 1 inch thick can be used as an alternative, providing the tension surfaces of the two pieces are parts of the original surfaces of the plate. Bend test pieces may be prepared by shearing or machining and the rough edges may be removed with a file before testing.

Mechanical Properties—Plates

314 The tensile properties determined on each test and check test piece are to comply with the requirements of Table I for the particular grade of steel.

Each bend test piece is to withstand cold bending through 180° without fracture over a former with a maximum radius as given in Table I for the grade of steel.

Additional Tests Before Rejection

315 Where either the tensile test or bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the plate, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the plate is to be judged by the results of the duplicate test or tests and not by the original test or tests which failed. If any one of the retests fails the plate is unacceptable.

However, at the discretion of the Surveyor and if requested by the maker, the plate may be heat treated and offered for further testing. In this connection the results of the previous tests are to be disregarded.

STEEL SECTIONS AND STAY BARS

Carbon and Carbon-Manganese Steel Sections and Stay Bars

316 Provision is made for carbon and carbon-manganese steel sections and stay bars having tensile strengths ranging from 26 to 32 tons/in.^{2} These are graded on mechanical properties as follows:—

Bar or Section	*Grade in Table I*
Angles, Tees and other Sections	2 and 3
Longitudinal Stay Bars	2 and 3
Combustion Chamber Stay Bars	2

Where any of these sections or bars is to be welded to the pressure parts of a boiler or pressure vessel the composition of the grade of steel is to comply with the requirements of 306(a) or 306(b).

Other Grades or Types of Steel

317 Where it is proposed to use either a steel of a grade other than those permitted in 316 or a low alloy steel, particulars of the chemical composition, mechanical properties and heat treatment are to be submitted for approval.

Number of Tests—Sections and Bars

318 For each size of section or bar rolled from the same charge the numbers of tensile test pieces required are as undernoted:—

Sections and Bars over $1\frac{3}{4}$ inches diameter	8 or less	1 tensile test
	9 to 29	2 tensile tests
	30 or over	1 tensile test for 15 or part of 15
Bars $1\frac{3}{4}$ inches diameter and under	20 or less	1 tensile test
	21 to 99	2 tensile tests
	100 or over	1 tensile test per 50 or part of 50

A bend test piece is to be taken from each section as rolled. For each tensile test required from bar material, a bend test is also to be made.

Tensile and Bend Test Pieces for Sections and Bars

319 For sections the tensile test pieces are to be prepared in accordance with the requirements of 312 and 313. For bars, tensile test pieces may be of either the full section as rolled or may be machined to a convenient size, provided the area of the reduced portion is not less than 0·5 square inch. Any of the gauge lengths given in Table I may be used.

Bend tests from sections are to be prepared and tested in accordance with the requirements for plate material. Bars may be tested on either the full section as rolled or on a section reduced by machining to a diameter of not less than 1 inch.

Mechanical Properties—Sections and Bars

320 The tensile properties determined on each test piece are to comply with the requirements of Table I for the particular grade of steel or approved specification.

Each bend test piece is to withstand cold bending through an angle of 180° without fracture over a former with a maximum radius as given in Table I for the grade of steel or as otherwise approved.

Additional Tests Before Rejection

321 Where either the tensile or bend test, or both, fail, and the Surveyor considers the fractured test pieces or the results obtained therefrom do not fairly represent the quality of the section(s) or bar(s), duplicates of the test or tests which failed are to be made if requested by the maker. For a single section or bar the pieces for retest are to be cut adjacent to the original test material. For batches, one of the pieces for retest is to be taken from that position and the other from a different section or bar in the batch.

If any one retest fails the sections or bars are unacceptable but at the discretion of the Surveyor and on request of the maker either each item in a batch may be tested separately or the items may be heat treated and offered for further testing.

Seamless Receivers

322 In the case of seamless receivers, the rules for material will be the same as for boiler shells, but the permissible extension may be 2 per cent less than that required for boiler plates.

The thicknesses of seamless receivers are to be verified by the Surveyor before the ends are closed in, and at this time the Surveyor is to select and mark the test pieces required from either of the open ends of the tube.

The test pieces are to be subjected to the same heat treatment as that given to the receivers.

Section 4

RIVET BARS AND MANUFACTURED RIVETS

Testing of Material

401 All material from which rivets are manufactured is to be tested.

Rivets are not to be manufactured from steel or ingot iron bars in which the sulphur segregates and other non-metallic substances are concentrated in the core. To ensure this, a sulphur print is to be taken from the material of each charge, and where the weight of bars as rolled from one charge exceeds 10 tons, additional sulphur prints may be taken.

Number of Tests

402 In the case of steel bars, one tensile test piece is to be taken from each charge used for rivet bars ; but where the weight of bars as rolled from one charge exceeds 10 tons, an additional tensile test is to be made from each further 10 tons or portion thereof.

403 In the case of wrought iron bars, two tensile tests shall be taken from every 3 tons or portion thereof in each batch of any order presented for inspection, except that, in the case of lots of 1 ton or less, one tensile test shall be accepted.

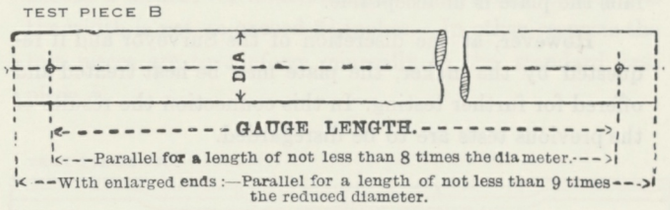
404 In the case of ingot iron bars, one tensile test piece is to be taken from each charge used for rivet bars ; but where the weight of bars as rolled from one charge exceeds 10 tons, an additional tensile test is to be made from each further 10 tons or portion thereof.

405 For rivet bars of steel or ingot iron one dump test is to be made for each tensile test.

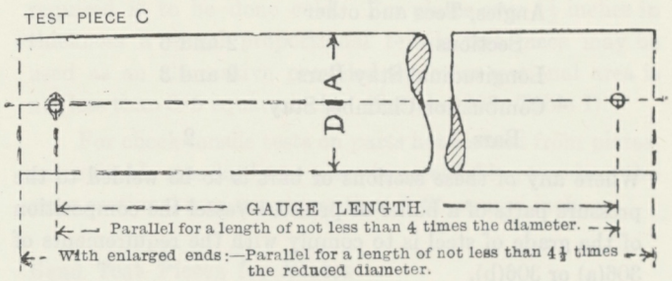
Tensile Test Pieces

406 Bars may be tested full size as rolled, or they may be turned down to a convenient size, and if tested 1 inch in diameter, or under, the test piece is to have a gauge length of eight times the diameter. Where enlarged ends are used, the length of the parallel portion is not to be less than nine times the reduced diameter of the test piece (*see* standard test piece B).

The sectional area of the test piece is not to be less than $\frac{1}{4}$ square inch.



407 Where bars are above 1 inch diameter, and are tested full size as rolled, or have been turned down and the resulting test piece is above 1 inch diameter, a gauge length of four times the diameter may be used if preferred by the manufacturer, in which case an increased elongation will be required, as specified in 409. Where enlarged ends are used, the length of the parallel portion is not to be less than 4·5 times the reduced diameter of the test piece (*see* standard test piece C).



Straightening of Test Pieces

408 Any straightening of test pieces which may be required is to be done cold.

Tensile Tests

409 The tensile strengths and elongations of rivet bars are to be within the following limits:—

Material	Tensile Strength Tons/sq. in.	Minimum Elongation	
		Gauge Length	
		4 × d (Test piece C)	8 × d (Test piece B)
Steel	26—30	30%	25%
Wrought Iron	21—25	—	22%
Ingot Iron	21—25	30%	25%

Dump Test

410 Short lengths, equal to twice their diameter, cut from the rivet bars shall, when cold, withstand without fracture being compressed to half their length.

Nicked Bend Tests

411 In the case of wrought iron bars one nicked bend test shall be taken from each 3 tons of material or portion thereof in each batch of any order presented for inspection.

412 The test pieces shall be lightly and evenly nicked on one side with a sharp cutting tool, and bent back at this point through an angle of 180 degrees. They shall show a clean fibrous fracture, free from slag or dirt or any coarse crystalline structure.

Manufactured Rivets

413 Rivets selected by the Surveyor from the bulk are to withstand the tests described in 414 to 416.

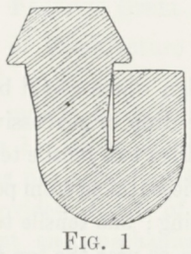


FIG. 1

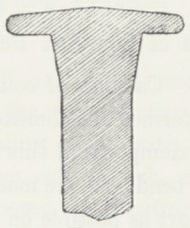


FIG. 2

414 The rivet shanks are to be bent cold, and hammered until the two parts of the shank touch in the manner shown in Fig. 1, without fracture on the outside of the bend.

415 The rivet heads are to be flattened, while hot, in the manner shown in Fig. 2, without cracking at the edges. The heads are to be flattened until their diameter is 2·5 times the diameter of the shank.

416 In the case of steel or ingot iron rivets, samples are to be selected by the Surveyor for examination by means of sulphur prints, to ensure that the material is free from marked central segregation.

Section 5

STEEL CASTINGS

Process of Manufacture

501 Steel for castings is to be made by the acid open hearth, basic open hearth or electric furnace process or by such other process as may be approved by the Committee and is to contain not more than 0·05 per cent sulphur or 0·05 per cent phosphorus.

Heat Treatment

502 The heat treatment of castings is to be carried out in a properly constructed furnace having adequate means of temperature control and the furnace must permit of the whole casting being uniformly heated to the necessary temperature as follows :—

Castings are to be fully annealed within a temperature range of 850° C. to 930° C., the temperature depending on composition.

Crank webs and combined crank web and pin casting after rough machining are to be stress relieved within a temperature range of 630° C. to 650° C., followed by furnace cooling. Other important engine components which in service are subject to dynamic loading are to be similarly heat treated if required.

Where it is desired to adopt other heat treatments, particulars are to be submitted for consideration.

Testing and Inspection

503 The tests and inspections described in this Section are to be made, preferably at the place of manufacture prior to despatch, but in the event of any casting proving unsatisfactory in the course of preparation or erection, such casting is to be rejected notwithstanding any previous certificate of satisfactory testing.

504 The tensile strength and ductility are to be determined from standard test pieces (*see* 507), which are to be prepared from pieces cast on the casting. These pieces are not to be cut or partially cut from the castings until the heat treatment of such castings has been completed, nor until they have been stamped by the Surveyor. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

505 Where the castings are to be used for purposes for which cast iron is ordinarily employed they need not be submitted to tensile and bend tests, but they are to be submitted to the hammering tests specified in 514.

Number of Tests

506 At least one tensile test and one cold bend test are to be taken from each casting. In castings of complex design, referred to in 513, at least two tensile tests and two cold bend tests are to be taken. Where a casting is made from more than one charge of steel, at least four tensile tests and four cold bend tests are to be made upon pieces cast as far apart

as possible, some test pieces being taken from as near the top, and others from as near the bottom of the casting as practicable. Where a number of charges are all mixed in one ladle before casting they may be considered as a single charge.

Dimensions of Tensile Test Pieces

507 The standard tensile test pieces are to be turned so as to have a diameter of ·564 inch with a gauge length of 2 inches, or a diameter of ·798 inch with a gauge length of 3 inches, or a diameter of ·977 inch with a gauge length of $3\frac{1}{2}$ inches.

Tensile Tests

508 The tensile breaking strength determined from test pieces of standard dimensions is to be between the limits of 26 and 35 tons per square inch with an elongation of not less than 20 per cent measured on the standard test piece.

In the case of machinery parts such as boiler mountings, valve chests, and other important machinery castings, the tensile breaking strength is to be between the limits of 28 and 35 tons per square inch, with a minimum elongation of 20 per cent measured on a standard test piece.

For cast steel crank webs or combined crank webs and pins, the tensile strength of the material is to be between the limits of 28 and 35 tons per square inch and the yield point of the material is to be not less than half the tensile strength. The sum of the tensile strength, in tons per square inch, and the percentage elongation is to be not less than 57.

Dimensions of Bend Test Pieces

509 The bend test pieces are to be machined either to a rectangular section 1 inch by $\frac{3}{4}$ inch with the edges rounded to a radius of $\frac{1}{16}$ inch or to a diameter of 1 inch.

Bend Tests

510 The bend test pieces are to withstand, without fracture, being bent cold as foilows :—

For crank webs and combined crank webs and pins, through an angle of 180°, the internal radius of the bend being not greater than $\frac{3}{4}$ inch.

For other castings, through an angle of 120°, the internal radius of the bend being not greater than 1 inch.

The bending may be performed either by pressure or by blows, and rectangular section test pieces are to be bent over the thinner section.

Additional Tests before Rejection

511 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the casting, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the casting is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

Percussive Tests

512 Stern frames cast in one piece are to be let fall on hard ground (excavations being made to take bosses and other projections) after being raised through an angle of 45 degrees. Stern frames cast in more than one piece, rudders, steering quadrants, crossheads and tillers, are to be dropped on hard ground from a height of from 7 to 10 feet according to the design, shape, and weight of the casting.

Castings of Complex Design

513 Castings of complex design which would be liable to be deformed if submitted to the drop or percussive test, may be exempt from this test provided two tensile tests and two cold bend tests are made upon pieces taken from positions as far apart as possible on each casting; one tensile test and one bend test should be taken from as near the top and the others from as near the bottom of the casting as practicable.

Hammering Tests

514 All castings are to be slung up and well hammered to satisfy the Surveyors that the casting is sound and without flaw. For large castings the hammer used for this test is to be not less than 7 lb. weight. In the case of castings which are subjected to the percussive tests mentioned in 512, the hammering tests are to be applied after the percussive tests.

Non-Destructive Testing

515 Castings of crank webs and combined crank webs and pins are to be examined by magnetic crack detection and for this purpose the surfaces are to be (*a*) cleaned or pickled and coated with a suitable white paint or (*b*) machined or (*c*) smoothed by grinding as may be required by the Surveyors. The surfaces are not to be hammered, peened or treated in any way that would invalidate the examination.

In the case of other large castings, the Surveyor may request a supplementary examination either by radiography, ultrasonic or other approved methods of non-destructive testing in order to determine the soundness of the castings.

The examination should be carried out at positions mutually agreed upon by the Surveyor and manufacturer where experience shows that cavities or contraction cracks are most likely to occur.

Where apparatus for non-destructive testing is not available at the foundry, the examination of crank webs and combined crank webs and pins by magnetic crack detection is to be carried out elsewhere, but in the case of other large castings, the Surveyor may request the soundness to be verified by drilling small holes. The Surveyor and manufacturers should agree on the location and depth of these holes, which are subsequently to be tapped and properly filled with a screwed plug.

Branding

516 Every casting, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Surveyor indicating that the casting has complied with the Society's requirements.

Ferritic Steel Castings for Turbines

Process of Manufacture

517 Cast steel turbine cylinders and associated castings may be made from any of the types of steel shown in Table 1. Other suitable low alloy steels, with tensile strengths not exceeding 45 tons per square inch, may be used provided details of the proposed composition, heat treatment and mechanical properties are submitted for consideration and approval.

The ladle analysis is to comply with the composition given in Table 1 or with the approved specification.

In all cases the steel used is to be made at an approved works by the open hearth or electric furnace process.

Heat Treatment

518 The castings are to be heat treated in properly constructed furnaces having adequate means of temperature control and the furnace must permit of the whole casting being uniformly heated to the necessary temperature.

All castings are to be fully annealed within a temperature range of 1560° F. (850° C.) to 1740° F. (950° C.), the temperature depending on the composition. Alloy steel castings are subsequently to be normalised followed by tempering at a temperature of 1110° F. (600° C.) to 1200° F. (650° C.), or as otherwise approved.

Removal of Surplus Material

519 Special precautions are to be taken to avoid damage to castings when any surplus metal is removed by flame cutting. Such metal should be removed before final heat treatment of the castings and the affected areas are to be subsequently dressed by grinding or chipping and grinding, and examined by a suitable magnetic crack detection method.

Examination and Repair of Castings

520 Castings are to be examined by the Surveyor on completion of the annealing operation. The surfaces may be pickled but must be suitably cleaned for examination. The surfaces are not to be extensively hammered, peened or treated in any way that may invalidate the inspection.

At changes of section, surfaces are to be smoothed by grinding or coated with a suitable white paint and examined by magnetic crack detection. The Surveyor may request a supplementary examination either by radiography, ultrasonic or other approved methods of non-destructive examination in order to determine the soundness of the casting. The examination should be carried out at positions mutually agreed upon by the Surveyor and manufacturer, where experience shows that cavities or contraction cracks are most likely to occur.

When defects are found in a casting, the Surveyor is to satisfy himself whether the number and size of the defects are such that the casting can be efficiently repaired. If found repairable, the defects are to be removed to his satisfaction and in a form suitable for welding. Welding of the affected parts is to be undertaken by a procedure, the

Table 1

Type of Steel	Carbon	Carbon Manganese	½ % Mo.	1% Cr. ½ % Mo.
Carbon ... ... %	0·25 max.	0·25 max.	0·25 max.	0·25 max.
Manganese ... %	0·5 to 1·0	1·0 to 1·5	0·5 to 1·0	0·5 to 0·8
Silicon ... ... %	0·15 to 0·5	0·15 to 0·5	0·15 to 0·5	0·15 to 0·5
Sulphur ... ... %	0·050 max.	0·050 max.	0·050 max.	0·050 max.
Phosphorus ... %	0·050 max.	0·050 max.	0·050 max.	0·050 max.
Chromium ... %	—	—	—	0·8 to 1·4
Molybdenum ... %	—	—	0·4 to 0·7	0·45 to 0·65

essential elements of which have been tested previously by the manufacturers and approved by the Surveyor. The welding is to be done under cover in positions free from draughts and adverse weather conditions by competent welders with adequate supervision. All welding is to be to the satisfaction of the Surveyors.

The castings are then to be stress relief heat treated at a temperature of not less than 1110° F. (600° C.). Where possible, however, low alloy steel castings are to be repaired by welding before normalising and tempering. On completion of welding and stress relief heat treatment, the welds and adjacent metal are to be smoothed and proved by magnetic crack detection. The stress relieving temperature is not to exceed the temperature at which a casting was previously tempered.

Test Material

521 Unless otherwise approved, test blocks are to be cast integral with the castings and are to be of sufficient size to provide specimens for mechanical tests. Test material is not to be detached from a casting until all heat treatments, other than stress relieving after rough machining, as required by H 419, are completed.

The test blocks are only to be flame cut from castings when the process neither damages the surfaces of the castings, nor affects the characteristics of the test material.

Number of Tests

522 At least one tensile and one bend test piece are to be taken from each casting.

Mechanical Properties

523 Tensile test pieces are to be of the round proportional type with a gauge length of $4\sqrt{A}$. The cross sectional area is not to be less than 0·25 square inch.

The tensile strength of the steel is to be within the limits given in Table 2 or within the limits of the approved specification. In all cases the elongation is not to be less than 20 per cent and the reduction in area not less than 30 per cent.

TABLE 2

Type of Steel	Range of Tensile Strength
Carbon	28–35 tons/square inch
Carbon Manganese ...	28–35 ,, ,, ,, ,,
½% Mo.	28–40 ,, ,, ,, ,,
1% Cr. ½% Mo.	30–45 ,, ,, ,, ,,

524 The bend test piece is to be machined to a diameter of 1 inch or to a rectangular section 1 inch by ¾ inch with the edges rounded to a radius of $\frac{1}{16}$ inch.

The test piece is to withstand, without fracture, being bent cold through an angle of 120° over a former of radius not more than 1 inch. Bending may be performed either by pressure or by blows and is to be over the thinner section for rectangular section test pieces.

Additional Tests before Rejection

525 Where either the tensile test or bend test or both fail and the Surveyor considers that the results may not fairly represent the quality of the casting, two additional test pieces may be taken. If possible one is to be taken from the test block used for the original tests and the second from another test block. In such cases the quality of the casting is to be judged on the results of two retests and not on the results of the original tests which failed.

If the results of the mechanical tests and retests fail to meet the requirements of 523 and 524, the manufacturer may reheat-treat the casting provided the Surveyor's consent is obtained. Castings so treated are to be presented for further complete mechanical tests.

Branding

526 Every casting to be marked in accordance with 516.

Section 6

INGOT STEEL FORGINGS

Process of Manufacture

601 Ingot steel for forgings is to be made by the open hearth process, acid or basic, or by such other process as may be approved by the Committee.

602 The forgings are to be sound and are to be made from sound ingots; all important forgings such as stern frames, rudder heads and main pieces of rudders upon which arms are shrunk, crank and other shafts, connecting rods and piston rods, are to be gradually and uniformly forged. The sectional area of the body of the forging (as forged) is not to exceed one-fifth of the sectional area of the original ingot, and no part of the forging (as forged) is to have more than two-thirds of the sectional area of the original ingot.

603 Ingots are to be cast in chilled moulds with the larger diameter or cross section uppermost, and with efficient refractory feeder heads, the sectional area of any part of the forging (as forged) is not to exceed :—

One-third of the sectional area of the ingot where the length at any diameter is greater than its diameter.

Two-thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., a collar.

Heat Treatment

604 All important ingot steel forgings are to be suitably heat treated in a properly constructed furnace, which must permit of the whole forging being uniformly heated throughout to the necessary temperature. If the forging be subsequently heated for any further forging, it is again to be similarly heat treated.

Testing and Inspection

605 The tests and inspections described in this Section are to be made, preferably at the place of manufacture prior to despatch ; but, in the event of any forging proving unsatisfactory in the course of preparation or erection, such forging is to be rejected notwithstanding any previous certificate of satisfactory testing.

606 The tensile strength and ductility are to be determined from standard test pieces (*see* 608) which are to be prepared from sample pieces cut lengthwise from the forging from a part of not less sectional dimensions than the body of the forging. In the case of crank webs the test pieces are to be taken crosswise from the webs as rolled or forged (*see* H 208 and H 608). Such standard test pieces are to be machined from the sample pieces without forging down, and the sample pieces are not to be detached from the forging until the heat treatment of such forging has been completed. The test pieces are to be stamped by the Surveyor after the heat treatment. All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the conditions herein described are fulfilled.

Number of Tests

607 At least one tensile and one cold bend test piece are to be taken from each forging or multiple forging. In the case of forgings or multiple forgings exceeding both 3 tons in weight and 8 feet in length, one tensile test and one cold bend test piece are to be taken from each end of each forging or multiple forging.

Dimensions of Tensile Test Pieces

608 The standard tensile test pieces are to be turned so as to have a diameter of ·564 inch with a gauge length of 2 inches, or a diameter of ·798 inch with a gauge length of 3 inches, or a diameter of ·977 inch with a gauge length of $3\frac{1}{2}$ inches.

In cases where the dimensions of the forging will not permit the use of one of these test pieces, any other standard round test piece can be used, provided it is of the largest practicable size and has a gauge length equal to four times the square root of the cross sectional area.

Tensile Tests

609 The tensile breaking strength determined from test pieces of standard dimensions is to be between the limits of 28 and 40 tons per square inch, with a range not exceeding 4 tons per square inch in any one forging, and in no case is the sum of the tensile breaking strength and percentage of elongation, measured on the standard test piece, to be less than 57 for test pieces cut longitudinally. Where the tensile test pieces are required to be taken transversely this sum is to be not less than 52.

610 Stern posts, propeller posts, rudders, and other ship forgings which are to be forge welded may be made of specially soft open hearth ingot steel, such steel to have a tensile breaking strength between the limits of 22 and 26 tons per square inch, with an elongation on the standard test piece of not less than 35 per cent for 22 ton steel and 31 per cent for 26 ton steel; in no case is the sum of the tensile breaking strength and corresponding elongation to be less than 57. The remaining tests and requirements are to be as prescribed for ordinary ingot steel.

Dimensions of Bend Test Pieces

611 The bend test pieces are to be machined to a rectangular section 1 inch wide by $\frac{3}{4}$ inch thick, with the edges rounded to a radius of $\frac{1}{16}$ inch.

Bend Tests

612 The bend test pieces are to withstand, without fracture, being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below, for test pieces taken longitudinally :—

Up to 32 tons per square inch	$\frac{1}{4}$ inch.
Above 32 tons and up to 36 tons per square inch ...	$\frac{3}{8}$ inch.
Above 36 tons and up to 40 tons per square inch...	$\frac{5}{8}$ inch.

Where the test pieces are required to be taken transversely, the internal radius of the bend should be not greater than $\frac{1}{2}$ inch, $\frac{3}{4}$ inch and $1\frac{1}{4}$ inches respectively, for the tensile strengths as stated above.

They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

Additional Tests before Rejection

613 Where either the tensile test or the bend test, or both, fail, and the Surveyor considers the fractured test piece or test pieces, or the results obtained therefrom, do not fairly represent the quality of the forging, duplicates of the test or tests which failed are to be made if requested by the maker. In such cases the quality of the forging is to be judged by the result of the duplicate test or tests and not by the original test or tests which failed.

General

614 The requirements as to heat treatment and testing are intended to apply to rudder heads and main pieces of rudders upon which arms are shrunk, to shafts of all descriptions, also to connecting rods and piston rods which require to be made in several heats. They are not intended to apply to small forgings which during their last stage of manufacture are uniformly heated throughout.

Special Quality Steel for Forgings

615 Where steel material is proposed having tensile strength other than that specified in this Section, the particulars of the mechanical properties of the material should be submitted for consideration.

Branding

616 Every forging, after it has withstood satisfactorily the prescribed tests, is to be clearly and distinctly marked by the Surveyor indicating that the forging has complied with the Society's requirements.

Ferritic Steel Forgings for Turbines, Compressors and Turbine Driven Generators

General

617 Ferritic steel used for the manufacture of forgings for turbine rotors, discs and spindles, turbine driven generator rotors and compressor rotors is to be made at an approved works by the open hearth, electric furnace or other approved process.

618 Ingots are to be cast in chill moulds with the larger section uppermost, and with efficient refractory feeder heads.

619 The forgings may be made of carbon steel or alloy steel. The composition of the steel is to be restricted as follows:—

Carbon	0·45% maximum
Silicon	0·15% to 0·45%
Sulphur	0·050% maximum
Phosphorus ...	0·050% maximum

Where mechanical tests are required from forgings in either the radial or the tangential direction or both, the sulphur and the phosphorus contents of the steel are not to exceed 0·040 per cent each.

Specifications of alloy steel forgings giving the proposed chemical composition, heat treatment and mechanical properties are to be submitted for approval with the plans of the components.

When it is proposed to use rotors of welded construction the compositions of the steel for the forgings are to be submitted for special consideration. These are to comply with the above limits of composition except that generally the carbon content is not to exceed 0·25 per cent.

620 The steelmaker is to provide details of the cast analysis of the steel used for each forging and the general details of heat treatment.

621 All forgings are to be sound and free from harmful defect. Forgings may be rejected if harmful defects are revealed during machining, notwithstanding acceptance during earlier stages of manufacture.

622 Orders and drawings for rotor forgings are to state whether the rotor is intended for propulsion or auxiliary machinery, and the shaft horse power of auxiliary turbines. In the case of a rotor which is to be tested for thermal stability the maximum operating temperature and the proposed test temperature are also to be stated.

Manufacture of Forgings

623 Thermal treatments of the steel are to be such as to avoid the formation of hair line cracks.

624 The forgings are to be gradually and uniformly forged from sound ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentages of the total weight from the top of the ingot:—

Weight of ingot	*Minimum top discard*
Below 2 tons ...	15 per cent
2 to 5 tons ...	18 ,, ,,
5 to 10 tons ...	22 ,, ,,
Over 10 tons ...	25 ,, ,,

625 For rotor forgings the sectional area of any part (as forged) is not to exceed one half of the average sectional area of the ingot. Where an upsetting operation is included in the manufacturing procedure the above requirement is to apply to the sectional area of the upset bloom and not to the ingot.

626 For spindle forgings the sectional area of any part (as forged) is not to exceed one third of the average sectional area of the ingot except at collars where the area is not to exceed two thirds of the sectional area of the ingot.

627 Turbine discs are to be forged or stamped from cylindrical pieces which have been hot cut or machined from a bloom or a billet. The thickness of any part of a disc (as forged or as stamped) is to be not more than one half of the length of the piece from which it was formed.

Heat Treatment

628 Forgings are to be carefully heat treated in properly constructed furnaces. At a suitable stage of manufacture they are to be re-heated above the upper critical point to refine the grain, cooled in an approved manner and then tempered to produce the desired mechanical properties.

Where forgings receive their main heat treatment prior to machining they are to be stress relieved at an intermediate machining stage.

The tempering and stress relieving temperatures are to be not less than 1020° F. (550° C.) in the case of carbon steels and 1110° F. (600° C.) in the case of alloy steels. The holding times and subsequent cooling rates are to be such that the forging in its final condition is free from harmful residual stresses.

The stress relieving temperature is not to exceed the temperature at which the forging was previously tempered.

Number of Tests

629 Sufficient material is to be left on forgings to provide specimens for mechanical tests. Excess test material is not to be completely severed from a forging until all the required mechanical tests have been completed with satisfactory results.

Test pieces are to be machined from pieces which are not to be cut from the forging until all heat treatment has been completed. In this connection a thermal stability test does not form part of the heat treatment of a turbine rotor forging.

630 At least one longitudinal tensile and one cold bend test piece are to be taken to represent the material of each forging (or multiple forging) excluding discs. In the case of forgings (or multiple forgings) exceeding both 3 tons in weight and 6 feet in length not less than one tensile and one cold bend test are to be taken from each end of each forging (or multiple forging).

631 For rotor forgings of all main propulsion machinery and of auxiliary turbines exceeding 1500 s.h.p. tangential and, where dimensions permit, radial tensile and bend tests are also to be taken from the end of the body corresponding to the top end of the ingot.

632 For each turbine disc, at least one tensile and one bend test piece are to be cut in a tangential direction from material at the hub.

Mechanical Properties

633 Tensile test pieces of the round proportional type are to be used with a gauge length of $4\sqrt{A}$. For longitudinal and tangential tests the cross sectional area is to be not less than 0·25 square inch and for radial tests not less than 0·10 square inch.

For carbon steel forgings the tensile strength is to be specified as a range of 5 tons per square inch within the limits of 28 to 45 tons per square inch. For alloy steel rotor forgings the specified range is to be 8 tons per square inch within the limits of 28 to 58 tons per square inch. For discs and other alloy steel forgings the specified range is also to be 8 tons per square inch within the limits of 28 to 68 tons per square inch.

In all cases the tensile strength of the steel is to be within the specified and approved range.

Where more than one tensile test piece is taken from a single forging, the tensile strengths are to be within the specified range but for alloy steels these are not to differ by more than 6 tons per square inch.

634 Unless otherwise specified and approved, the yield stress or 0·5 per cent proof stress, as appropriate for the type of steel, is not to be less than 50 per cent of the actual tensile strength for normalised material and not less than 60 per cent of the actual tensile strength for low alloy material in the quenched and tempered condition.

635 The reductions of area at fracture as determined on tensile test pieces are not to be less than:—

35% for longitudinal tests
30% for tangential tests
20% for radial tests.

636 The percentage elongations at fracture of tensile test pieces are to comply with the requirements given in Table 1.

637 If the percentage of elongation of any tensile test specimen is less than that prescribed in Table 1, and any part of the fracture is outside the middle half of the gauge length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

638 Bend test pieces are to be machined to a section of $\frac{3}{4}$ inch by $\frac{3}{8}$ inch. The test pieces are to be bent cold without fracture to angles of not less than 180° for a longitudinal test piece; 150° for a tangential test piece; and 120° for a radial test piece.

The maximum radius of the formers is given in Table 1.

639 Where either the tensile test or bend test or both fail, and the Surveyor considers that the results may not fairly represent the quality of the forging, two additional test pieces may be taken from a similar part of the forging if requested by the maker. In such cases the quality of the forging is to be judged on the results of the two retests and not on the results of the original tests that failed.

640 If the results of mechanical tests and retests on a forging fail to meet the requirements of 633 to 639 inclusive, the maker may reheat-treat the forging providing the Surveyor's consent is obtained. Forgings so treated are to be presented for further complete mechanical tests.

641 Alternative requirements of National Standard and other specifications, which provide reasonable equivalents in mechanical properties, may be accepted if approved. Impact tests in place of bend tests may also be accepted if approved.

Additional Inspections

642 Rotor forgings for propulsion machinery and for auxiliary turbines exceeding 1500 s.h.p. are to be hollow bored for internal examination. The surfaces of the bores are to have a fine, smooth finish. The Surveyor is to be provided with an optical instrument of suitable magnification to examine the bores.

At the discretion of the Surveyor, alternative methods of proving the internal soundness of such forgings may be accepted.

643 The end faces of rotor forgings are to be machined to a fine smooth finish at the forge for the purposes of examination.

644 The end faces of the boss and the bore surface of each turbine disc are to be machined to a smooth finish and examined by a suitable method of magnetic crack detection.

Stability Testing of Turbine Rotors

645 Thermal stability tests after heat treatment and rough machining of the turbine rotors referred to in H 408 are to be undertaken in properly constructed furnaces, using accurate and reliable measuring equipment. Each test is to be carried out in accordance with the following recommended procedure:—

(*a*) Five bands are to be machined concentric with the axis of rotation. Two of these are to be reference bands and are to be positioned at or near the locations of the bearings. The remaining three bands are to be test bands located one as near as possible to the mid-length, and the other two near each end of the body. Where the length of a rotor is such that five bands cannot be provided, alternative proposals are to be submitted to the Surveyor for his approval.

(*b*) Four positions, 90° apart, are to be stamped A, B, C and D on the coupling end of the rotor.

(*c*) The whole of the body and as much of the shaft at either end as will include the positions of the glands are to be enclosed in the furnace. In the case of a rotor having an overhung astern wheel, the astern wheel is also to be enclosed in the furnace during the first test. (*See* H 408.)

(*d*) The rotor is to be rotated at a uniform and very slow speed.

(*e*) The deflections at all bands are to be recorded at the A, B, C and D positions. Initial cold readings are to be taken prior to heating.

(*f*) The rotor is to be heated uniformly and slowly. Temperatures are to be recorded continuously at the surface of the rotor and if practicable in the bore at the mid-length of the body. Under no circumstances is the surface temperature to exceed the temperature at which the rotor was tempered. During heating the rate of rise of temperature is to be such as to avoid excessive temperature gradients in the rotor.

(*g*) The maximum or holding temperature is to be not less than 28° C. (50° F.) above the maximum operating temperature of the rotor. For the purposes of the test the holding period is to start when the rotor has attained a uniform and specified temperature. The rotor is to be held under the specified temperature conditions until not less than three consecutive hourly readings of deflections show the radial eccentricity to be constant within 0·00025 inch on all test bands.

(*h*) The turbine rotor is to be rotated during cooling until the temperature is not more than 100° C. (212° F.). The rate of cooling is to be such as to avoid excessive temperature gradients in the rotor.

(*i*) Final cold readings are to be taken.

646 The movements of the axis of the rotor in relation to the reference bands are to be determined from polar plots of the deflection readings.

The radial movement of the shaft axis as determined by the difference between the final hot and the final cold movements is not to exceed 0·001 inch on any one band.

As verification that test equipment and conditions are satisfactory it is required that similar determinations of differences between initial cold and final cold movements do not exceed 0·001 inch on any one band.

If the results of the test on a rotor fail to meet either or both of the above requirements, the test may be repeated if requested by the maker and agreed by the Surveyor.

647 In the case of a rotor failing to meet the requirements of a thermal stability test, the rotor is deemed unacceptable. Proposals for the rectification of thermal instability of a rough machined rotor are to be submitted for special consideration.

Branding

648 Every forging to be marked in accordance with 616.

TABLE 1

Minimum Specified Tensile Strength	Minimum Percentage Elongation for gauge length of $4\sqrt{A}$ *			Maximum radius of former in inches for bend test		
				180°	150°	120°
Tons per square inch	L.	T.	R.	L.	T.	R.
28	28	23	20	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$
30	28	23	20	$\frac{3}{8}$	$\frac{3}{8}$	$\frac{3}{8}$
35	25	20	18	$\frac{1}{2}$	$\frac{1}{2}$	$\frac{1}{2}$
40	22	18	16	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
45	20	16	14	$\frac{3}{4}$	$\frac{3}{4}$	$\frac{3}{4}$
50	18	14	12	$\frac{3}{4}$	$\frac{3}{4}$	—
55	17	13	—	1	1	—
60	17	12	—	1	1	—

L.—For longitudinal tests.
T.—For tangential tests.
R.—For radial tests.
Intermediate values are to be obtained by interpolation.

* A is the cross sectional area of the tensile test piece.

Yield stress or 0·5% proof stress (*See* 634)

Not less than 50% of the actual tensile strength for normalised material.

Not less than 60% of the actual tensile strength for low alloy material in the quenched and tempered condition.

Reduction of Area (*See* 635)

Not less than 35% for longitudinal tests.
„ „ „ 30% for tangential tests.
„ „ „ 20% for radial tests.

Section 7

SEAMLESS STEEL DRUMS FOR BOILERS

Process

701 The steel is to be made by the open hearth process acid or basic.

Discard

702 Sufficient discard shall be made from the top and bottom of each ingot to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled.

Forging

703 The forging shall be made from a solid cast ingot, punched, bored or trepanned, or alternatively hollow cast ingots may be used. The resultant wall in the case of the solid cast ingot, or the wall of the hollow ingot, as cast, shall be reduced in thickness by at least two-thirds in the process of forging.

The Committee will be prepared to give consideration to the circumstances of any special case.

Heat Treatment and Testing

704 Sufficient material shall be left on each end of each forging to enable tangential tests to be taken. These tests are to consist of one tensile test and one bend test from each end. In the case of open-ended drums the test material shall not be parted off before heat treatment, but, if the drums are closed in, the test rings may be parted prior to this operation ; subsequently the test rings and the forging shall be simultaneously heat treated in the same furnace.

If desired, test pieces may be heated for the purpose of straightening, but this operation must not cause any alteration in the sectional area of the test pieces, which are subsequently to be heat treated simultaneously with the drum.

Tensile Tests

705 The tensile breaking strength is to be between the limits of 28 and 40 tons per square inch, but the difference in the tensile strengths at each end of a forging is not to exceed 4 tons per square inch.

The percentage of elongation measured on a standard test piece (*see* P 608) is to be between 29 and 17, and in no case is the sum of the tensile breaking strength and corresponding elongation to be less than 57.

Bend Tests

706 Test pieces 1 inch by $\frac{3}{4}$ inch are to be capable of being bent cold through an angle of 180 degrees, the internal radius of the bend being not greater than that specified below :—

Up to 32 tons per square inch	$\frac{1}{4}$ inch.
Above 32 tons and up to 36 tons per square inch...	$\frac{3}{8}$ inch.
Above 36 tons and up to 40 tons per square inch...	$\frac{5}{8}$ inch.

Retesting

707 Should either the tensile test or the bend test fail, two further specimens may be tested and if the results obtained from both are satisfactory the forging shall be accepted. In the event of either or both retests failing, the forging may be again heat treated and re-presented for test.

Section 8

REDUCTION GEAR PINIONS AND GEAR WHEELS

General

801 Steels used for pinions, pinion sleeves and wheel rims are to comply with the following requirements. Steels for other parts used in the construction of gearing are to comply with the requirements of P 3, P 5 or P 6 as may be applicable.

The steel is to be made by the acid open hearth, electric furnace or other approved process and is to contain not more than 0·04 per cent of sulphur or phosphorus.

Ingots are to be cast in chill moulds with the larger diameter or cross section uppermost, and with efficient refractory feeder heads.

A certificate giving the actual chemical analysis of the steel is to be provided in all cases.

802 Specifications for materials of pinions, pinion sleeves, wheel rims, flexible couplings and quill shafts giving chemical analysis, heat treatment and mechanical properties are to be submitted for approval with the plans of gearing, as required by H 503.

803 All forgings are to be sound and free from defects. Forgings may be rejected after the cutting of teeth if defects are then revealed, notwithstanding acceptance during earlier stages of manufacture.

Pinions

Materials

804 Pinions are to be made from approved alloy steels which in the heat treated condition have tensile strengths between 40 and 76 tons per square inch. The specified range of tensile strength is not to exceed 6 tons per square inch for any forging (*see also* H 502).

Any of the following type steels will be accepted for this service within the range of tensile strengths for which they are suitable:—

3% Ni
$3\frac{1}{2}$% Ni
$1\frac{3}{4}$% Ni+Cr+Mo
$2\frac{1}{2}$% Ni+Cr+Mo
3% Ni+Cr+Mo
$4\frac{1}{4}$% Ni+Cr+Mo
3% Cr+Mo

NOTE.—The percentage figures are applicable to the first element only: for instance $1\frac{3}{4}$% Ni+Cr+Mo is to be interpreted as a steel having a nominal Ni content of $1\frac{3}{4}$% with, in addition, appropriate contents of Cr and Mo.

Where it is desired to use other alloy steels or case-hardening steels full details are to be submitted for consideration.

Manufacture of Forgings

805 The forgings are to be gradually and uniformly forged from ingots from which at least 5 per cent of the total weight of the ingot is removed from the bottom and not less than the following percentage of the total weight from the top of the ingot:—

Weight of Ingot	*Minimum top discard*
Below 2 tons	15 per cent
2 to 5 ,, ...	18 ,, ,,
Over 5 ,, ...	25 ,, ,,

806 The sectional area of any part of the forging (as forged) is not to exceed:—

One half of the sectional area of the ingot where the length at any diameter is greater than its diameter or for any part in which teeth are to be cut.

Two thirds of the sectional area of the ingot where the length at any diameter is less than its diameter, e.g., a collar.

Sleeves are to be hollow forged or hollow rolled where practicable.

807 The forgings are to be made with sufficient material on the portion on which the teeth will be cut to allow not less than the following amounts being machined from surfaces of the finished forging before heat treatment, but leaving $\frac{1}{4}$ inch on all surfaces:—

Large forgings for pinions 6 inches and over in diameter over the toothed portion when finished—1 inch on diameters.

Small forgings for pinions under 6 inches in diameter over the toothed portion when finished—$\frac{3}{4}$ inch on diameters.

Heat Treatment

808 The forgings are to be normalised and tempered or oil-hardened and tempered in accordance with the approved specification.

Number of Tests

809 Tensile and impact tests are to be provided as follows:—

For each pinion forging (or multiple forging) not exceeding 8 inches in body diameter and 48 inches in overall length, a set of longitudinal test pieces is to be taken from one end; where the overall length exceeds 48 inches a set is to be taken from both ends.

In addition to the foregoing, a set of transverse test pieces is to be taken from one end of the body portion where the body diameter exceeds 8 inches and the total length of body portion does not exceed 30 inches; where this length exceeds 30 inches a set is to be taken from both ends. In cases where the difference in diameters between the body and journal does not permit the selection of transverse tests, these tests may be taken from the ends of the forgings.

For each pinion sleeve forging (or multiple forging) not exceeding 30 inches in length, a set of circumferential test pieces is to be taken from one end; where the length exceeds 30 inches a set is to be taken from both ends.

Batch Testing

810 Where a number of pinion forgings of the same dimensions are forged separately from the same cast and heat treated together in batches, and each forging does not exceed either a length of 48 inches or a weight of 3 cwts. as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of longitudinal and transverse tests from each of these forgings in accordance with the foregoing and including sulphur prints may be taken as representative of the batch. The results of these tests are to be confirmed by Brinell tests carried out on all forgings in accordance with 812.

Mechanical Properties

811 The mechanical properties of the forgings, after heat treatment, are to comply with the requirements of Table 1.

Test pieces taken from the circumference of pinion sleeves are to be regarded, for Table 1 requirements, as longitudinal tests where sleeves are hollow-forged and as transverse tests where sleeves are solid-forged and machined hollow (*see* 806).

TABLE 1—MECHANICAL PROPERTIES FOR PINIONS

MATERIAL—ALLOY STEEL

Specified minimum tensile strength tons/sq. in.	Minimum yield stress tons/sq. in.	Minimum elongation on 2 inches per cent		Minimum Izod, ft. lb.		Heat Treatment condition
		Longitudinal	Transverse	Longitudinal	Transverse	
40	28	23	16	20	15	Normalised and tempered
40	28	23	16	35	20	Oil-hardened and tempered
45	33	22	15	34	18	
50	38	20	14	32	17	
55	44	18	13	30	15	
60	48	17	12	28	*	
65	52	14	10	26	*	
70	58	13	9	22	*	

* Transverse impact tests are to be made and the results recorded.

Tensile tests are to be made on a standard test piece of 2 inches gauge length and 0·564 inch diameter.

Impact tests are to be made on Izod test specimens 10 mm. square with a V notch 2 mm. deep having an included angle of 45 degrees with 0·25 mm. radius at root. Alternatively, a round test specimen 0·45 inch diameter with a V notch may be used.

Hardness Tests

812 Hardness tests are to be taken on all forgings after machining to $\frac{1}{4}$ inch over the finished diameter after heat treatment. The impressions are to be taken at each end of two diameters at right angles in three different positions over each toothed portion of the pinion. The forging will be considered sufficiently uniform if the difference between the highest and lowest value does not exceed 30 in Brinell Numbers, or their equivalent.

Sulphur Prints

813 Sulphur prints are to be taken over the whole of the body portions of the forging in which teeth are to be cut, and in addition from each end of the body portions to verify that the steel is clean and free from harmful segregations.

When considered necessary by the Surveyors, these prints are to be supplemented by magnetic crack detection examinations or other approved tests.

GEAR WHEELS

814 Wheel rims and solid-forged wheels are to be made from approved steels which in the heat treated conditions have tensile strengths between 30 and 66 tons per square inch. The specified range of tensile strength is not to exceed 5 tons per square inch for the carbon steel and 6 tons per square inch for the alloy steel forgings.

Any of the following type steels will be accepted for this service up to a tensile strength of 45 tons per square inch within the range for which they are suitable.

Carbon Steels (·25%C to ·55%C)
1% Ni
1% Cr+Mo

Where it is proposed to use other alloy steels of greater tensile strength, or case-hardening steels, full details are to be submitted for consideration.

Manufacture of Forgings

815 Wheels and rims are to be gradually and uniformly forged or rolled from ingots from which the following top and bottom discards have been taken. If rims are made from trepanned ingots sufficient discard shall be made from the top and bottom to ensure soundness in the portion used for forging, and sulphur prints may be taken to demonstrate that this condition has been fulfilled. If the rims or wheels are made from solid ingots the top and bottom discards are to be not less than required in the case of pinions (*see* 805). Rolled bar is not to be used.

Heat Treatment

816 Wheel and rim forgings are to be normalised and tempered or oil-hardened and tempered in accordance with the approved specification.

Number of Tests

817 Tensile and bend tests are to be provided for carbon steels and tensile and impact tests for alloy steels as follows:—

For single wheel or rim forgings greater than 8 feet in diameter or 3 tons in weight and for multiple forgings,

one set of circumferential tests is to be taken from each end of the forging from positions diametrically opposed, provided that in the case of multiple forgings all the portions cut from it are heat treated together. For smaller single wheels or rims a set of circumferential test pieces is to be taken from one end of the forging.

Batch Testing

818 Where a number of wheels or rims of the same dimensions are forged from the same cast and heat treated together in batches, and do not exceed 3 cwts. each as forged, the following test procedure may be adopted.

Sufficient material for test purposes shall be left on 5 per cent of the forgings constituting a heat treatment batch, the minimum number being two forgings per batch. Sets of transverse tests from each of these forgings in accordance with the foregoing may be taken as representative of the batch.

Mechanical Properties

819 The mechanical properties of the forgings, after heat treatment, are to comply with the requirements of Table 2.

The tensile and impact test pieces are to be of the type and size described in 811.

The bend test pieces are to be machined to a rectangular section of 1 inch wide by $\frac{3}{4}$ inch thick for carbon steels not exceeding 40 tons per square inch tensile strength and $\frac{3}{4}$ inch wide by $\frac{3}{8}$ inch thick where the tensile strength exceeds 40 tons per square inch. The edges are to be rounded to a radius of $\frac{1}{16}$ inch in each case. These test pieces are to withstand, without fracture, being bent cold through an angle of 180 degrees over a former having a radius not greater than that specified in Table 2. They are to be bent over the thinner section. The bending may be performed either by pressure or by blows.

TABLE 2—MECHANICAL PROPERTIES FOR WHEELS AND RIMS

Material	Heat Treatment condition	Specified minimum tensile strength tons/sq. in.	Minimum yield strength tons/sq. in.	Minimum elongation on 2 inches per cent	Radius of former inch	Minimum Izod ft. lb.
Carbon Steels	Normalised and tempered	30	15	27	$\frac{1}{4}$	Not applicable
		35	17	22	$\frac{3}{8}$	
		40	20	20	$\frac{5}{8}$	
		45	22	18	$\frac{3}{4}$	
Alloy Steels	Normalised and tempered	40	22	22	Not applicable	*
		45	25	20		*
		50	27	18		*
		55	30	16		*
Alloy Steels	Oil-hardened and tempered	40	28	23	Not applicable	35
		45	33	22		34
		50	38	20		32
		55	44	18		30
		60	48	17		28

* Impact tests are to be made and the results recorded.

Hardness Tests

820 Hardness tests are to be made on all wheels and rims as in 812 except that for carbon steels the difference between the highest and lowest value is not to exceed 20 in Brinell Numbers, or their equivalent, for steels of tensile strength not exceeding 40 tons per square inch and 30 in Brinell Numbers for steels over 40 tons per square inch.

Sulphur Prints

821 Sulphur prints are to be taken from the ends of the wheel rim to verify that the steel is clean and free from harmful segregations. Where considered necessary by the Surveyors these prints are to be supplemented by further prints from the cylindrical surfaces and by magnetic crack detection examinations or other approved tests.

Surface-hardened and Case-hardened Pinions and Wheels

822 Forgings for pinions and wheels of the above types are to comply generally with the manufacturing and inspection requirements of the preceding paragraphs and with the following test requirements.

Tensile and impact tests are to be made to verify that the sub-surface mechanical properties comply with the approved specification. For surface-hardened parts these tests are to be made at the forge in accordance with requirements of 809 and 817: for case-hardened parts the forgings are to be inspected and identified at the forge and the tests made at the engine works or other agreed place after the gears are hardened and finally heat treated. Tests are to be provided as stated in 809 and 817, except that for pinions transverse tests from the body pieces will not be required.

Test blocks for case-hardened parts are to have dimensions such that they will be representative of the forgings and for pinions they are to be not less in diameter than the journals. They are to be blank-carburised and heat treated with the pinion or wheel before being cut up for test purposes. The test pieces are to be cut from the blocks near the surface.

In addition to the aforementioned tensile and impact tests, hardness tests are to be made on the teeth, when hardened and ground, to verify that the surface hardness and sub-surface tensile strength of the teeth comply with the approved specification.

Where it is desired to adopt alternative tests to the foregoing, full details are to be submitted for consideration.

The teeth of all surface- and case-hardened pinions and wheels are to be examined for cracks and other imperfections by magnetic crack-detecting equipment or other approved means.

Section 9

BOILER TUBES AND PRESSURE PIPES

General

901 The following requirements and tolerances are based generally on British practice. Alternative requirements and tolerances of British and other national standard specifications may be accepted where they provide reasonable equivalents to the requirements of this Section.

When the tubes or pipes are of a type or made from an alloy steel for which provision is not made in this Section, they will be required to comply with the terms of an approved specification or with such tests, appropriate to the material, as may be approved.

Requirements for wall thickness, permissible operating temperatures for different steels and service limitations for various types of tubes and pipes are given in the following paragraphs :—

E 508 to E 512—Steel pressure pipes.

J 1201 to J 1208—Smoke tubes and other tubes for cylindrical boilers.

J 1402 & J 1403
J 1611 & J 1612 } Boiler, superheater and downcomer tubes for water tube boilers.

902 The steel is to be made by the open hearth, electric furnace or other approved process, and is to show on analysis not more than 0·05 per cent sulphur or phosphorus.

903 Where the designed operating metal temperature exceeds 750°F., the steel, whether carbon or alloy, is to be of the non-segregated and fully killed type. In order to avoid intergranular penetration by non-ferrous metals, tubes or pipes of alloy steel are not to come into contact with such metals or their compounds during manufacture.

A certificate giving the chemical analysis of the steel for each cast is to be provided for all tubes and pipes.

904 Cold drawn carbon steel tubes or pipes are to be annealed or normalised after drawing. Low alloy molybdenum and chromium molybdenum steel tubes or pipes are to be annealed or normalised ; other alloy steel tubes or pipes are to be given a heat treatment suitable for the materials concerned.

905 All tubes and pipes are to be smooth and practically concentric throughout their length and are to be examined externally and internally and be free from defects. Ends are to be ground where necessary to facilitate examination.

Boiler Tubes. (Smoke tubes, water tubes and superheater tubes.)

906 Tubes for water tube boilers and superheaters are to be seamless unless otherwise specially approved; those under $1\frac{1}{2}$ inches external diameter are to be cold drawn.

907 Tolerances on thickness and diameter of straight tubes are not to exceed those given in Table 1.

908 Every tube is to be tested, at the makers' works, by hydraulic pressure to the requirements of Table 2.

The makers' certificate of hydraulic test may be accepted.

909 Tubes of the same diameter, thickness and material are to be presented for mechanical testing in batches of 100 tubes. Two tubes are to be selected indiscriminately from at least two of the batches and one tube from each remaining batch. The selected tubes are to be subjected to tensile, flattening and expanding tests, as detailed in the following paragraphs.

910 Tensile test pieces may be strips cut from the tubes or lengths of full section tube. In the case of hot finished tubes where the tube ends only have been annealed the test pieces are to be taken from the un-annealed portion of the tube. The mechanical properties are to comply with the requirements of Table 3.

911 Expanding tests are to be made on both ends of all selected tubes using a drift expander having a total included angle of from 40°–60°. The tube ends are to withstand when cold and without signs of cracking the increases in diameter given in Table 4.

912 Flattening tests are to be made on one selected tube from each batch. This tube is to withstand being flattened when cold and without cracking, to the extent given in Table 4, at three different positions; one position is to be near the middle of the length and all are to be in different planes.

913 Should one of the selected tubes fail to comply with any one or more of the tests specified in 910 to 912, two further tests of the same kind are to be made on two additional tubes selected from the same batch. If failure again occurs the batch of tubes is to be rejected as unsatisfactory.

TABLE 1—TOLERANCES

TYPE OF TUBE	OUTSIDE DIAMETER	PERMISSIBLE TOLERANCES	
		THICKNESS	DIAMETER
Hot Finished	Up to $2\frac{1}{2}$ inches	$+17\frac{1}{2}\%$ $-\ 7\frac{1}{2}\%$	$+\frac{1}{64}''$ $-\frac{1}{32}''$
	Over $2\frac{1}{2}$ inches and up to $4\frac{1}{2}$ inches	$+15\%$ $-\ 5\%$	$+1\%$ -1%
Cold Drawn	All sizes	$+10\%$ $-\ 5\%$	$+0$ -1%

TABLE 2—HYDRAULIC TEST PRESSURES

WORKING PRESSURE lb. PER SQUARE INCH	HYDRAULIC TEST PRESSURE lb. PER SQUARE INCH
Up to and including 500 ...	1000
Over 500 up to and including 1000	2 × working pressure
Over 1000	Working pressure + 1000

Pressure Pipes

914 Pipes may be seamless, or of other approved type as required in E 509 to E 511, according to the service for which they are intended.

915 Tolerances on thickness and diameter, of straight pipes, are not to exceed those given in Table 5.

TABLE 3—MECHANICAL PROPERTIES

TYPE OF STEEL	TYPE OF TEST PIECE	RANGE OF TENSILE BREAKING STRENGTH, TONS PER SQUARE INCH	MINIMUM ELONGATION, PER CENT			
			Less than $\frac{1}{4}$ inch thick		$\frac{1}{4}$ inch thick and over	
			on 8 inches	on 2 inches	on 8 inches	on 2 inches
Carbon	Strip	20 to 28	18	28	20	30
	Full section		23	—	25	—
$\frac{1}{2}$% Mo.	Strip	25 to 35	17	23	19	25
	Full section		21	—	23	—
1% Cr. $\frac{1}{2}$% Mo.	Strip	27 to 37	16	22	18	24
	Full section		20	—	22	—

TABLE 4—EXPANDING AND FLATTENING TESTS

THICKNESS OF TUBE S.W.G.	EXPANDING TEST		FLATTENING TEST		
	Increase in O.D. per cent		Distance apart of inner surfaces		
			Carbon Steel		Alloy Steel
	Carbon Steel	Alloy Steel	Cold Drawn	Hot Finished	
Up to 10	15	$12\frac{1}{2}$	Touching	3 times the thickness	
Over 10 and up to 6		$9\frac{1}{2}$	2 times the thickness		
Over 6 and up to 3	12	$6\frac{1}{2}$			
Over 3	$9\frac{1}{2}$				

TABLE 5—TOLERANCES FOR SEAMLESS PIPES

TYPE OF PIPE	PERMISSIBLE TOLERANCES					
	THICKNESS		OUTSIDE DIAMETER			BORE
	$t/D > 3\%$	$t/D > 3\%$	Up to $1\frac{29}{32}$ inch O.D.	Over $1\frac{29}{32}$ inch O.D.	Under 6 inches bore	6 inches bore and over
Hot Finished	+15% −15%	$+12\frac{1}{2}$% $-12\frac{1}{2}$%	$+\frac{1}{64}$ inch $-\frac{1}{32}$ inch	+1% −1%	—	—
Cold Drawn	+10% −10%		—	—	+1% −1%	$+\frac{1}{32}$ inch $-\frac{1}{16}$ inch

916 Every pipe, while straight and with plain ends, is to be hydraulically tested at the makers' works to the pressure derived from the formula given below or to 1000 lb. per square inch, whichever is less.

For Seamless Carbon and Alloy Steels

$$\text{Test Pressure} = t/D \times S \times 1200$$

Where t = nominal thickness, in inches

D = nominal outside diameter, in inches

S = minimum tensile breaking strength, in tons per square inch.

The makers' certificate of hydraulic test may be accepted.

917 Mechanical tests are to be taken in the following proportions from pipes of the same diameter and thickness and from the same cast.

Up to and including $4\frac{1}{2}$ inches O.D.... 1 in 40 or part thereof

Over $4\frac{1}{2}$ inches and up to 6 inches O.D.... 1 in 10 or part thereof

Over 6 inches O.D. ... ... 1 in 5 or part thereof

The mechanical tests required are a tensile test and either a flattening or bend test. Flattening tests are to be made on pipes up to $4\frac{1}{2}$ inches O.D. and bend tests on pipes over $4\frac{1}{2}$ inches O.D.

918 Tensile test pieces may be strips cut from the pipes or lengths of full section pipe. The mechanical properties are to comply with the requirements of Table 6.

919 A flattening test, on pipes up to $4\frac{1}{2}$ inches O.D., is to be made on a ring not less than $1\frac{1}{2}$ inches long, cut from one end of each selected pipe. This ring is to withstand being flattened, when cold and without cracking, until the distance apart of the inner surfaces of the pipe is 4 times its thickness or $\frac{2}{3}$ of the bore, whichever is less.

920 A bend test on pipes over $4\frac{1}{2}$ inches O.D., is to be made on a strip not less than $1\frac{1}{2}$ inches wide cut circumferentially from one end of each selected pipe. This strip is to withstand being bent double in the direction of original curvature, when cold and without cracking, over a round bar or former of diameter as follows :—

Up to $\frac{3}{8}$ inch thickness ... 3 times the pipe thickness

Over $\frac{3}{8}$ inch thickness ... 4 times the pipe thickness or $\frac{2}{3}$ of the bore whichever is less.

921 Should a pipe selected for testing fail to comply with any one or more of the tests specified in 918 to 920 two further tests of the same kind are to be made from another pipe from the same batch. If failure again occurs the batch of pipes is to be rejected as unsatisfactory.

TABLE 6—MECHANICAL PROPERTIES

TYPE OF STEEL	TYPE OF TEST PIECE	RANGE OF TENSILE BREAKING STRENGTH, TONS PER SQUARE INCH	MINIMUM ELONGATION, PER CENT			
			Less than $\frac{1}{4}$ inch thick		$\frac{1}{4}$ inch thick and over	
			on 8 inches	on 2 inches	on 8 inches	on 2 inches
Carbon	Strip	23 to 30	18	28	20	30
	Full section		23	—	25	—
$\frac{1}{2}$% Mo.	Strip	25 to 35	17	23	19	25
	Full section		21	—	23	—
1% Cr. $\frac{1}{2}$% Mo.	Strip	27 to 37	16	22	18	24
	Full section		20	—	22	—

Section 10

BRONZE PROPELLERS AND PROPELLER BLADES

General

1001 The requirements of this section are applicable to propeller castings of the following non-ferrous materials:—

(a) Manganese bronze or high tensile brass with a minimum tensile strength of 28 tons per square inch.

(b) High tensile aluminium bronzes with a minimum tensile strength of 40 tons per square inch.

Particulars of chemical composition and mechanical properties of proprietary alloys are to be submitted for information.

1002 Where it is proposed to use other non-ferrous materials or different grades of type (a) and (b) alloys, full particulars are to be submitted for consideration.

1003 Castings are to be clean and free from harmful defects and are to be tested and inspected at the makers' works. In the event of any casting proving defective in the course of subsequent machining such casting may be rejected notwithstanding any previous certification of satisfactory test.

Provision of Test Samples

1004 Test samples, sufficient for the preparation of at least three test pieces, are to be provided for each casting. The test samples are to be of approved form and may be separately-cast or integral with the casting.

1005 Separately-cast test samples:— These may be adopted at works where Surveyors are in frequent attendance. The procedure for identifying the test samples and the propeller casting is to be approved by the Surveyors who in cases of doubt may require that check analyses of sample and casting be made.

The samples are to be separately cast at the same time and from the same metal as the casting which they represent, and are to be poured into moulds of the same material as that used for the casting. Where a casting is made from more than one ladle test samples are to be provided for each ladle.

1006 Integral test samples:— These are to be provided as blocks cast on the surfaces of the casting. Samples gated from the casting are not acceptable.

NOTE.—With the object of obtaining sound test blocks and of permitting free contraction of the propeller casting, it is preferable that the test blocks be arranged axially on the hub instead of on the blades at mid-radii.

Mechanical Properties

1007 Test pieces are to be ·564 inch diameter with a gauge length of 2 inches or of other similar standard. At least one tensile test is to be made for each casting and for each ladle if 1005 is applicable. The test results are to comply with the requirements of the following table or of a specification specially approved.

If the first test piece fails to meet requirements, then the two remaining test pieces are to be broken; if these also fail the casting is to be rejected.

Material	Minimum Tensile Strength tons/in.²		Minimum Elongation per cent on 2" gauge length
	Integral test piece	Separately-cast test piece	
(a) Manganese Bronze	28	30	20
(b) Aluminium Bronze	40	42	15

NOTE.—The values in the table are applicable to test pieces and are not necessarily obtainable from all parts of the castings. In general it can be expected that the mechanical properties of a propeller, especially in the thick root sections of the blades, will be inferior to those of the test piece.

Section 11

ANCHORS

Process of Manufacture

1101 Anchors are to be made of forged ingot steel or of cast steel. The manufacturing process of forged ingot steel anchors is to comply with the relevant requirements of P 6, and that of cast steel anchors with the relevant requirements of P 5. Forged and cast steel anchor heads and cast steel shanks are to be subjected to the test requirements of these sections except that the percussive and hammering tests detailed in P 12 are to be substituted for the requirements of P 512, P 513 and P 514.

Where, however, more than one anchor head is poured from a charge one tensile and one bend test per charge will be accepted, provided all anchor heads from the charge are heat treated at the same time and under the same conditions. If the weight of a charge exceeds 3 tons, and more than one anchor is poured from the charge, a further tensile and bend test should be taken.

1102 Each important part of an anchor is to be plainly marked by the maker with the words "forged ingot steel" or "heat treated cast steel" as the case may be (or simply "forged steel" or "cast steel").

1103 Steel anchor shackles are to be made of forged ingot steel or cast steel as specified in 1101, but need not be submitted to the test requirements of P 5 and P 6.

Proof Tests of Anchors

1104 All anchors weighing more than 168 lbs. inclusive of stock, if fitted, are to be tested in accordance with the requirements of the following table and the certificates of test produced.

Weight	Test	Weight	Test	Weight	Test	Weight	Test	Weight	Test	Weight	Test
Cwts.	Tons	Cwts.	Tons	Cwts.	Tons	Cwts.	Tons	Cwts.	Tons	Cwts.	Tons
1	3·40	26	25·65	51	43·00	76	56·75	101	67·65	126	76·65
2	4·50	27	26·40	52	43·65	77	57·25	102	68·00	127	76·95
3	5·50	28	27·15	53	44·25	78	57·65	103	68·40	128	77·25
4	6·40	29	27·90	54	44·75	79	58·15	104	68·75	129	77·60
5	7·40	30	28·65	55	45·40	80	58·50	105	69·15	130	77·90
6	8·25	31	29·40	56	46·00	81	59·00	106	69·50	140	81·00
7	9·25	32	30·15	57	46·65	82	59·50	107	69·90	150	84·15
8	10·15	33	30·90	58	47·25	83	60·00	108	70·25	160	86·75
9	11·15	34	31·65	59	47·75	84	60·50	109	70·65	170	89·25
10	12·00	35	32·40	60	48·40	85	61·00	110	71·00	180	91·75
11	12·90	36	33·15	61	48·90	86	61·50	111	71·40	190	94·25
12	13·90	37	33·75	62	49·50	87	61·90	112	71·75	200	96·75
13	14·75	38	34·50	63	50·00	88	62·25	113	72·15	210	98·95
14	15·65	39	35·15	64	50·50	89	62·75	114	72·50	220	101·05
15	16·50	40	35·75	65	51·00	90	63·25	115	72·90	230	103·00
16	17·40	41	36·50	66	51·50	91	63·65	116	73·25	240	105·00
17	18·25	42	37·15	67	52·15	92	64·00	117	73·65	250	107·00
18	19·00	43	37·90	68	52·65	93	64·50	118	74·00	260	109·00
19	19·90	44	38·65	69	53·25	94	65·00	119	74·40	270	111·00
20	20·75	45	39·25	70	53·75	95	65·40	120	74·75	280	113·00
21	21·65	46	39·90	71	54·25	96	65·75	121	75·10	290	115·00
22	22·40	47	40·50	72	54·75	97	66·15	122	75·40	300	117·00
23	23·15	48	41·15	73	55·25	98	66·50	123	75·70	—	—
24	23·90	49	41·75	74	55·75	99	66·90	124	76·00	—	—
25	24·75	50	42·40	75	56·25	100	67·25	125	76·35	—	—

The weight given in the above Table is either for stockless anchors or for stocked anchors without the stock.
For intermediate weights the test may be obtained by interpolation.

Section 12

CAST STEEL ANCHORS

General

1201 All cast steel anchors are to be subjected to the percussive and hammering tests as detailed in this Section.

Percussive Test

1202 The anchor, or where anchors are made in more than one piece, each piece is to be raised a given height and then dropped on a steel or iron slab.

For weights of 15 cwts. and below, the height is to be 15 feet, and for weights above 15 cwts. the height is to be 12 feet.

The lowest part of the anchor or piece when suspended is to be at least the given height above the slab upon which it is to be dropped.

1203 An anchor of the Admiralty pattern is first to be raised vertically to the given height with its shank and arms in a horizontal position, and then let fall from that height.

It is then to be raised a second time to the given height and suspended with the crown downwards. Two steel or iron blocks are to be placed underneath it, and the anchor is to be let fall from this position so that one of the blocks receives it on the middle of one arm, and the other block receives it on the middle of the other arm.

1204 The slab for the horizontal test is to be of steel or iron, well laid on a solid concrete foundation to the satisfaction of the Surveyor.

1205 The blocks for the vertical test are to be solid and of sufficient height to prevent the crown of the anchor from touching the slab, and are to be to the satisfaction of the Surveyor.

Hammering Test

1206 Provided the percussive test has been satisfactory, the anchor or piece is to be slung and thoroughly hammered over its parts with a sledge hammer weighing not less than 7 lb., and is required to give under this treatment such a clear ring in all its parts as shall satisfy the Surveyor that the casting is sound and that no flaws have developed by the application of the preceding percussive tests.

Section 13

CHAIN CABLES, STREAM CHAINS AND STEERING CHAINS

Note:—For list of manufacturers of electrically welded and cast steel chain cables see Appendix to this Chapter.

1301 Chain cables and steering gear chain may be of wrought iron or of one of the following three grades:—

(I) Fire welded or electrically welded, of mild steel having a tensile breaking strength of 20–26 tons per square inch.

(II) Electrically welded, of mild steel having a tensile breaking strength of 26–32 tons per square inch.

(III) Electrically welded special steel or cast steel having an ultimate tensile breaking strength of 32–40 tons per square inch.

The method of manufacture adopted for electrically welded or cast steel chains must in the first place be approved.

The steel of which the cable is manufactured is to comply with P 1 and P 2 where applicable and is to satisfy the tests given in 1302 and 1303.

Special steel cable referred to in Table 53—Equipment is cable satisfying the requirements of grade (III) above and which has been tested as required for cables of special steel in 1305.

Tensile Tests

1302 From each group of bars of the same size taken from the same charge, two are to be selected and test pieces not greater than one inch in diameter complying with P 406 are to be used. The tensile breaking strength of the material is to be between the limits specified above for the particular type of chain for which the bars are intended. The elongation is not to be less than 25 per cent for steel having a breaking strength between 20 and 26 tons per square inch, 20 per cent for steel between 26 and 35 tons per square inch, and 15 per cent for steel above 35 tons per square inch.

Bend Tests

1303 A bend test is to be made from each group of bars. The bar is to withstand, without fracture, being doubled when cold until the sides are parallel, and the internal radius is equal to ·5 times the diameter of the bar when the tensile strength is 32 tons per square inch and under, or equal to the diameter of the bar when it is over 32 tons per square inch.

Heat Treatment

1304 Cables made of material other than wrought iron or mild steel having an ultimate tensile breaking strength of 20 to 26 tons per square inch are to be properly heat treated.

1305 All chain cables, stream and steering chains are to be tested in accordance with the requirements of the following tables and the certificates of test produced.

Stud Link Chain Cables

Minimum Size	CABLES OF WROUGHT IRON		CABLES OF SPECIAL STEEL		Minimum Weight per Length of 15 fms.	Minimum Size	CABLES OF WROUGHT IRON		CABLES OF SPECIAL STEEL		Minimum Weight per Length of 15 fms.
	Proof Test	Breaking Test	Proof Test	Breaking Test			Proof Test	Breaking Test	Proof Test	Breaking Test	
Ins.	Tons	Tons	Tons	Tons	Cwts.	Ins.	Tons	Tons	Tons	Tons	Cwts.
7/16	3·40	5·10	4·80	7·10	1¾	2½	112·50	157·50	157·50	220·50	47
½	4·50	6·75	6·30	9·50	2⅛	2 9/16	116·70	163·40	163·40	228·70	49½
9/16	5·65	8·40	7·90	11·80	2⅝	2⅝	120·90	169·25	169·25	237·00	52
⅝	7·00	10·50	9·80	14·70	3¼	2 11/16	125·10	175·15	175·15	245·20	54½
11/16	8·50	12·75	11·90	17·90	3⅝	2¾	129·30	181·00	181·00	253·40	57⅛
¾	10·15	15·15	14·20	21·20	4⅜	2 13/16	133·40	186·75	186·75	261·50	59⅞
13/16	11·90	17·80	16·60	24·90	5⅛	2⅞	137·60	192·65	192·65	269·70	62⅝
⅞	13·75	20·65	19·30	28·90	5⅞	2 15/16	141·70	198·40	198·40	277·70	65½
15/16	15·80	23·70	22·10	33·20	6¾	3	145·80	204·10	204·10	285·70	68⅜
1	18·00	27·00	25·20	37·80	7⅝	3 1/16	149·80	209·70	209·70	293·60	71¼
1 1/16	20·30	30·40	28·40	42·60	8⅝	3⅛	153·75	215·25	215·25	301·40	74¼
1⅛	22·75	34·15	31·90	47·80	9¾	3 3/16	157·70	220·75	220·75	309·10	77⅜
1 3/16	25·40	38·00	35·50	53·20	10⅞	3¼	161·60	226·20	226·20	316·70	80⅜
1¼	28·15	42·15	39·40	59·00	12	3 5/16	165·40	231·50	231·50	324·10	83⅝
1 5/16	31·00	46·50	43·40	65·10	13¼	3⅜	169·15	236·75	236·75	331·50	86⅞
1⅜	34·00	51·00	47·60	71·40	14½	3 7/16	172·75	241·80	241·80	338·50	90⅛
1 7/16	37·15	55·65	52·00	77·90	15⅞	3½	176·40	246·90	246·90	345·70	93½
1½	40·50	58·70	56·70	82·20	17¼	3 9/16	179·90	251·80	251·80	352·50	96¾
1 9/16	43·90	61·40	61·40	86·00	18¾	3⅝	183·25	256·50	256·50	359·00	100
1⅝	47·50	66·50	66·50	93·10	20	3 11/16	186·50	261·10	261·10	365·50	103⅜
1 11/16	51·25	71·75	71·75	100·50	21½	3¾	189·80	265·70	265·70	372·00	106⅝
1¾	55·15	77·15	77·15	108·00	23⅛	3 13/16	192·90	270·00	270·00	378·00	109⅞
1 13/16	59·15	82·75	82·75	115·90	24⅞	3⅞	195·90	274·25	274·25	384·00	113¼
1⅞	63·25	88·50	88·50	123·90	26⅝	3 15/16	198·80	278·30	278·30	389·65	116¾
1 15/16	67·50	94·50	94·50	132·30	28⅜	4	201·60	282·20	282·20	395·10	120⅝
2	72·00	100·80	100·80	141·10	30	4 1/16	204·20	285·90	285·90	400·25	124⅝
2 1/16	76·50	107·10	107·10	149·90	31⅞	4⅛	206·70	289·40	289·40	405·15	128⅝
2⅛	81·25	113·75	113·75	159·30	33¾	4 3/16	—	—	292·60	409·65	132¾
2 3/16	86·15	120·50	120·50	168·70	35⅞	4¼	—	—	295·80	414·15	136⅞
2¼	91·15	127·50	127·50	178·50	37⅞	4 5/16	—	—	298·70	418·20	141⅛
2 5/16	96·25	134·75	134·75	188·75	40	4⅜	—	—	301·40	422·00	145⅜
2⅜	101·50	142·10	142·10	198·90	42¼	4 7/16	—	—	303·80	425·35	149¾
2 7/16	106·90	149·65	149·65	209·50	44½	4½	—	—	306·15	428·60	154⅛

SHORT LINK CHAIN CABLES

Minimum Size	CABLES OF WROUGHT IRON OR MILD STEEL		CABLES OF SPECIAL STEEL		Minimum Weight per length of 15 fms.	
	Proof Test	Breaking Test	Proof Test	Breaking Test	Forged	Electric Welded
Ins.	Tons	Tons	Tons	Tons	Cwts.	Cwts.
$\frac{7}{16}$	2·25	4·50	3·20	6·40	2·0	1·5
$\frac{1}{2}$	3·00	6·00	4·20	8·40	2·5	1·9
$\frac{9}{16}$	3·75	7·50	5·30	10·60	3·0	2·4
$\frac{5}{8}$	4·65	9·25	6·55	13·10	3·5	3·0
$\frac{11}{16}$	5·65	11·25	7·95	15·90	4·0	3·6
$\frac{3}{4}$	6·75	13·50	9·45	18·90	4·8	4·3
$\frac{13}{16}$	7·90	15·80	11·10	22·20	5·5	5·0
$\frac{7}{8}$	9·15	18·25	12·85	25·70	6·4	5·8
$\frac{15}{16}$	10·50	21·00	14·75	29·50	7·3	6·7
1	12·00	24·00	16·80	33·60	8·3	7·6
$1\frac{1}{16}$	13·50	27·00	18·95	37·90	9·3	8·6
$1\frac{1}{8}$	15·15	30·25	21·25	42·50	10·4	9·6
$1\frac{3}{16}$	16·90	33·80	23·70	47·40	11·6	10·7
$1\frac{1}{4}$	18·75	37·50	26·25	52·50	12·9	11·8
$1\frac{5}{16}$	20·65	41·25	28·95	57·90	14·1	13·0
$1\frac{3}{8}$	22·65	45·25	31·75	63·50	15·5	14·3
$1\frac{7}{16}$	24·75	49·50	34·70	69·40	17·0	15·6
$1\frac{1}{2}$	27·00	54·00	37·80	75·60	18·4	17·0
$1\frac{9}{16}$	29·25	58·50	41·00	82·00	19·9	18·4
$1\frac{5}{8}$	31·65	63·25	44·35	88·70	21·5	19·9
$1\frac{11}{16}$	34·15	68·25	47·85	95·70	23·1	21·5
$1\frac{3}{4}$	36·75	73·50	51·45	102·90	25·0	23·1
$1\frac{13}{16}$	39·40	78·80	55·20	110·40	26·9	24·8
$1\frac{7}{8}$	42·15	84·25	59·05	118·10	28·9	26·5
$1\frac{15}{16}$	45·00	90·00	63·05	126·10	30·9	28·3
2	48·00	96·00	67·20	134·40	33·0	30·2

Section 14

STEEL WIRE TOWLINES, MOORING ROPES AND STANDING RIGGING; FIBRE ROPES

Note:—For list of manufacturers of steel wire towlines, mooring ropes and standing rigging see Appendix to this Chapter.

General

1401 Each manufacturer is required to provide on his premises machines suitable for making the prescribed tests satisfactorily, and the works are to be at all times open to the inspection of the Surveyors, who are empowered to retest any rope for which a certificate has been issued by the manufacturer. Periodical inspections should be held at intervals not exceeding two years.

Certificates

1402 Printed forms of certificates, approved by the Committee, are to be signed by the manufacturers, and will be supplied to them upon application to the Secretary.

Material

1403 The wire used in the manufacture of the ropes is to be drawn from steel billets made by the open hearth process and to have a tensile strength within the range shown in the table in 1405. The wire is to be of homogeneous quality, free from defects, and of smooth uniform finish.

Galvanising

1404 The wire is to be galvanised to the satisfaction of the Surveyors.

Construction of Ropes

1405 The construction of the wire rope and the ultimate tensile strength of the wire are given in the following table:—

Purpose	Construction of Rope			Construction of Strands	Ultimate tensile strength of wire
	Strands	Wire	Core		Tons per sq. in.
For Standing Rigging	6 of 7	Fibre		6 over 1	45 to 55
	6 of 19	Fibre		12 over 6 over 1	85 to 95
Mooring wires, Stream wires and Towlines	6 of 12	Fibre		12 over fibre core	85 to 95
	6 of 24	Fibre		15 over 9 over fibre core	85 to 95
	6 of 37	Fibre		18 over 12 over 6 over 1	85 to 95

Tests of Ropes

1406 A portion of each steel wire rope is to be tested to destruction and its ultimate breaking load must not be less than that given in the following table:—

Circumference	Type and Breaking Load					Circumference
	6 × 7	6 × 12	6 × 19	6 × 24	6 × 37	
Inches	Tons	Tons	Tons	Tons	Tons	Inches
1	1·8	2·0	3·1	2·6		1
1¼	2·9	3·1	4·7	4·3		1¼
1½	4·2	4·4	6·7	6·0		1½
1¾	5·8	5·9	9·1	8·5		1¾
2	7·6	8·0	12·4	10·9		2
2¼	9·5	10·5	16·3	14·2		2¼
2½	11·8	12·3	19·1	17·2		2½
2¾	14·3	14·8	22·9	20·5		2¾
3	17·1	17·6	27·0	25·0	27·3	3
3¼	20·1	21·1	32·5	28·9	29·8	3¼
3½	23·4	24·4	37·5	34·2	34·9	3½
4	30·0	32·3	49·5	43·6	46·5	4
4½	38·5	41·3	63·5	57·0	59·8	4½
5	47·5	49·5	76·0	68·9	74·7	5
5½			88·4	82·0	89·0	5½
6			104·5	96·3	107·0	6
6½				107·4	121·0	6½
7				123·5	140·0	7
7½					153·9	7½
8					173·9	8

1407 If facilities are not available for making the above tests on the rope, then a specimen is to be cut from the rope and each wire tested separately to destruction.

The breaking strength of the rope shall be considered to be the sum of the aggregate breaking loads of the individual wire less a percentage for laying up as follows:—

6 × 7	...	...	...	5 per cent
6 × 12	...	...	...	7½ per cent
6 × 19	...	...	...	10 per cent
6 × 24	...	...	...	10 per cent
6 × 37	...	...	...	15 per cent

1408 The wire shall stand being wrapped tightly eight times round its own diameter and subsequently unwrapped without showing any signs of fracture of the steel. Six wires or 5 per cent of the wires in the rope, whichever is the greater number, are to be subjected to this test.

1409 Fibre Ropes

Sizes and Tests of Fibre Ropes

Circumference	3-Strand (plain or Hawser laid)	4-Strand (Shroud laid)	9-Strand (Cable laid or Water laid)
Inches	Breaking Load		
	Tons	Tons	Tons
2½	2·8	2·5	
2¾	3·3	2·9	
3	4·0	3·5	
3¼	4·6	4·1	
3½	5·3	4·7	
3¾	6·0	5·3	
4	6·8	6·0	
4¼	7·6	6·7	
4½	8·5	7·5	
4¾	9·3	8·3	
5	10·3	9·2	6·5
5½	12·4	11·0	7·7
6	14·6	12·9	9·0
6½	17·0	15·1	10·3
7	19·6	17·4	11·8
8	25·2	22·3	14·9
9	31·5	28·0	18·5
10	38·6	34·2	22·4

Section 15

APPROVAL OF ELECTRODES FOR ARC WELDING IN HULL CONSTRUCTION

1501 The manufacturer's plant and method of production of the electrodes are to be such as to ensure reasonable uniformity in manufacture.

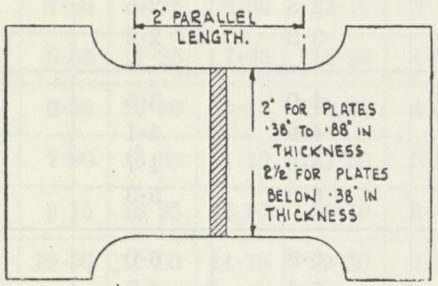
1502 Electrodes will be approved by the Committee subject to compliance with the following tests.

The test pieces are to be prepared in the presence of the Surveyor and all tests carried out under his supervision. The steel used in the preparation of the test pieces is to comply with the requirements of P 2 Grade A.

1503 All test specimens are to be prepared and tested in duplicate. If one specimen fails to satisfy the test, two further specimens may be prepared, both of which must prove satisfactory.

Butt Welds

1504 TENSILE TESTS—Tensile test specimens of the form shown in the sketch are to be prepared. One of the specimens is to be of the maximum thickness which would normally be welded with square edges, and others, which are to be welded with V butts, are to be ·38, ·62 and ·88 inch in thickness. The surfaces of the welded joints are to be rendered flush on both sides.



The mean tensile strength of the test specimens for each thickness is to be not less than 26 tons per square inch.

1505 BEND TESTS—Bend tests are to be made on specimens similar to those shown above from material ·38 and ·88 inch in thickness. These are to withstand bending without fracture through an angle of 90 degrees over a bar of diameter equal to four times the thickness of the test piece. The rough edges of the samples may be removed by filing or grinding, and the test is to be made so that the wide part of the V is in tension.

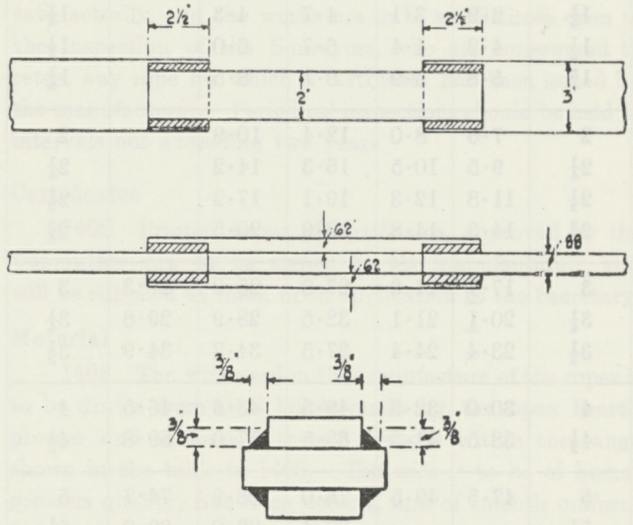
Deep Penetration Electrodes

1506 DEEP PENETRATION TESTS —Where it is desired by the manufacturer to demonstrate that an electrode has deep penetrating properties when used in the downhand welding position, the following test is to be made: two plates, of thickness equal to twice the diameter of the core of the electrode, are to be butt welded together with one downhand run of welding from each side. The plate edges are to be prepared square and ground smooth, and after tacking the gap is not to exceed 0·010 inch. The plates shall be at least 6 inches wide, and of such length as to accommodate, on each side, at least the run length of a complete electrode. The weld is to be sectioned transversely, polished and etched, and must show complete penetration throughout the joint.

The above test is to be carried out using the largest and also the smallest diameter of electrode being produced, but in the latter case not less than $\frac{1}{8}$ inch diameter. The test is to be made in duplicate for each diameter of electrode tested.

Shear Tests

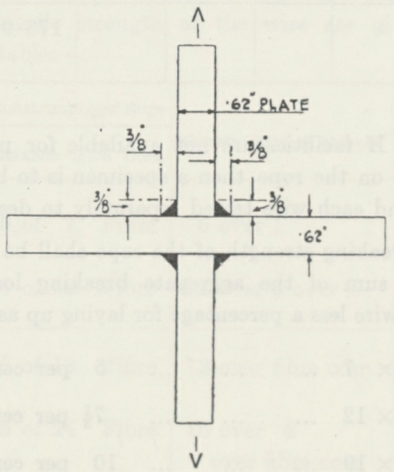
1507 Shear tests are to be carried out on specimens prepared as shown in the sketch.



The shear strength of the welds is to be not less than 17 tons per square inch, calculated on the throat thickness.

Fillet Weld Tests

1508 Fillet weld tests are to be made on samples 2 inches in width as shown in the sketch.



They are to withstand a tensile load, applied in the direction shown, of 73 × t tons, t being the throat thickness of the welds.

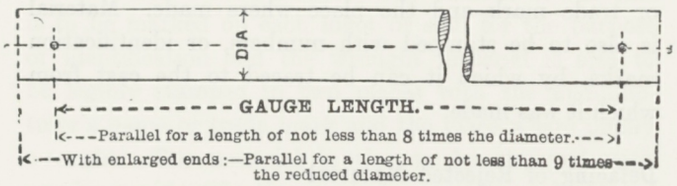
Vertical and Overhead Tests

1509 Where it is desired by the manufacturers to demonstrate that an electrode is suitable for vertical or overhead welding, tensile and bend tests are to be made from plates ·38 inch in thickness, together with fillet weld tests, as set forth in 1504, 1505 and 1508, for each position for which approval is sought.

An indication will be given in the list of approved electrodes of the positions of welding for which the electrode has been approved.

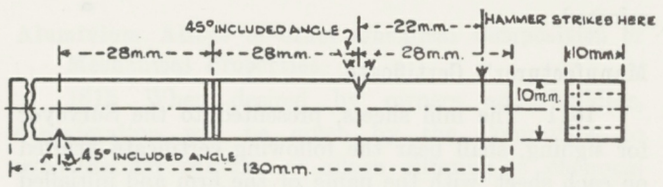
Deposited Material Tests

1510 Tensile, bend and impact tests are to be made on metal deposited from the electrode. The samples for the tensile and bend tests are to be prepared as shown in the sketch, the diameter being ·564 inch.



The minimum breaking strength is to be 26 tons per square inch and the minimum elongation 18 per cent. The samples are to withstand bending to 120 degrees without fracture over a bar having a diameter twice the diameter of the test piece.

The impact tests are to be made on a standard form of Izod test piece as shown in the sketch.



THREE NOTCH TEST PIECE.

The depth of the notch is to be 2 mm., the included angle 45 degrees, and the radius at the root ·25 mm.

The average value for each specimen is to be not less than 30 ft. lb. Other forms of impact test may be adopted with suitably modified values.

Chemical Analysis

1511 Chemical analyses of the metal of each type of electrode and of the deposited material of a weld made by the same electrode are to be supplied.

1512 The Committee is to be notified of any alteration proposed to be made in the process of manufacture subsequent to approval.

Maker's Certificate

1513 Each carton or package of approved electrodes is to contain a certificate from the manufacturer on the following lines :—

> "The —— Company certifies that the composition and quality of these electrodes conform with those of the electrodes used in making the test pieces submitted to and approved by the Committee of Lloyd's Register of Shipping."

Periodical Inspection of Makers' Works

1514 All establishments where approved electrodes are manufactured shall be subject to periodical inspection by the Surveyors. These visits will take place as may be considered necessary by the Committee, but at least once a year. On these occasions samples, selected by the Surveyors, of each of the electrodes manufactured by the makers and appearing in the Society's approved list, will be subjected to the tests given in 1515.

1515 Tensile, elongation and bend tests in duplicate are to be made on specimens of deposited material as set forth in 1510. The specimens for tensile and elongation tests may be ·424 inch in diameter with a gauge length of $1\frac{1}{2}$ inches; if this gauge length is adopted, the minimum elongation is to be 23 per cent.

1516 The Committee may require, in any particular case, such additional tests as may be considered necessary.

Section 16

ALUMINIUM ALLOY PLATES, BARS AND SECTIONS

Note:—For list of manufacturers of Aluminium Alloys for shipbuilding purposes see Appendix to this Chapter.

General

1601 Aluminium alloys used in the construction of ships classed, or proposed for classification, in the Society's Register Book are to be made at works recognised by the Committee and are to comply with the following requirements.

These requirements, however, are not intended to apply to sheets less than ·18 inch thick, or to angles less than $1\frac{1}{2}'' \times 1\frac{1}{2}'' \times ·18''$. Where material of these scantlings is used, the physical properties and chemical composition may be in accordance with a recognised specification for an alloy suitable for marine use.

Alloys whose chemical composition differs from these requirements will be specially considered.

Freedom from Defects

1602 The finished material is to be free from cracks, surface flaws and lamination.

Testing and Inspection

1603 The prescribed tests and inspections are to be made at the place of manufacture prior to despatch; but, in the event of any material proving unsatisfactory in the course of being worked into ships due to faults in manufacture, such material shall be rejected, notwithstanding any previous certificate of satisfactory testing, and such further tests of the material from the same cast may be made as the Surveyor may consider desirable.

Where a continuous melting process is employed for the production of ingots, a cast is to be defined as the amount of metal tapped from the furnace without any further addition having been made.

1604 All test pieces are to be selected by the Surveyor and tested in his presence, and he is to satisfy himself that the prescribed conditions are fulfilled.

1605 The manufacturer is to supply to the Surveyor at the time of test a certificate of the chemical composition of the material submitted for approval and, at the discretion of the Surveyor, samples may be selected from the material for the purpose of check analyses.

Additional Tests before Rejection

1606 Where any of the test pieces first selected by the Surveyor do not fulfil the test requirements, then:—

In the case of non-heat-treatable alloys, two further tests of the same kind may be made from the same plate, or section, but where either of these fail, the plate or section from which the test pieces were cut is to be rejected. In all such cases further tests are to be taken before any material from the same cast can be accepted.

In the case of heat-treatable alloys, the procedure laid down above is to be adopted, but the manufacturer may, should he so desire, re-heat-treat the whole of the material represented by the test piece before the two further test pieces are selected.

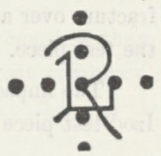
1607 Where a tensile test piece breaks outside the middle half of its gauge length, and the elongation is less than that required by the Rules, the test may, at the manufacturer's option, be discarded and another test made of the same plate or section.

Branding

1608 Every plate or section is to be clearly and distinctly marked by the manufacturer in two places with the Society's brand, thus:—  indicating that the material has complied with the Society's requirements.

1609 Material bearing this brand is not to be forwarded from the works until the prescribed tests have been made by the Surveyor and the mill sheets have been signed by him. All material is also to be stamped in two places with the manufacturer's name or trade mark and the place where made. Material is also to be stamped with numbers, or identification marks, by which it can be traced to the cast from which it was made.

Defacing of Rejected Material

1610 In the event of the material failing to withstand the prescribed tests, the Surveyor is to see that the Society's brand, stamped on the material by the manufacturer, has been defaced by punch marks extending beyond the brand in the form of a cross, thus:—  denoting that the material has been rejected.

Manufacturer's Certificate

1611 The mill sheets, presented to the Surveyor for signing, shall bear the following certificate printed on each sheet, with the name of the firm and initialled by the test house manager:—

"We hereby certify that the material described below satisfies the prescribed chemical composition and is that which has been satisfactorily tested in the presence of the Surveyor in accordance with the Rules of Lloyd's Register."

Facilities for Inspection

1612 The manufacturer is to adopt a system of marking which will enable all material presented for inspection to be traced to the original cast, and, in the case of heat-treatable material, to the particular batch in which it was heat-treated; a batch comprises all material simultaneously heat-treated in one furnace

load. The Surveyor must be given every facility for tracing all material to its respective casts and for witnessing the required tests. When the Surveyor is satisfied with the material and with the results of tests, he is to be furnished with two copies of the advice notes for his signature, one of which is to be forwarded by the manufacturer to the shipbuilder, and the other is to be forwarded by the Surveyor to the Surveyors at the port where the ship is to be built.

Aluminium Alloys not made where Wrought

1613 Where the alloy is not made at the works where it is wrought, a certificate is to be supplied to the Surveyor stating the name of the maker of the material, also the numbers of the casts for reference to the books of the maker. The number of the cast is to be marked on each ingot or slab for the purpose of identification and the wrought material is also to be legibly stamped in two places with the manufacturer's name or trade mark and the place where finally wrought. The material is also to be stamped with numbers or identification marks by which it can be traced to the cast from which it was made.

Additional Tests

1614 In addition to the tests described hereafter, the material may be subjected to additional tensile tests at the discretion of the Surveyors.

Aluminium Alloys of other Chemical Composition or Mechanical Properties

1615 When desired by owners and builders, consideration will be given by the Committee to proposals for the use of alloys differing in chemical composition or mechanical properties from those provided for in the Rules.

Tensile Test Pieces

1616 The proof stress, the tensile strength and the ductility are to be determined from standard test pieces. The test for proof stress shall be carried out on each selected test piece either from a stress strain curve, by drawing a line parallel to the straight portion of the curve and distant from it by an amount representing the required maximum permanent elongation, thus determining the stress at which line and curve intersect; or by subjecting the test piece to the specified minimum proof stress and removing the load, when the test piece shall not have acquired a permanent elongation, measured by an extensometer, greater than that required by the Rules.

1617 For material more than ·875 inch in thickness the width of the test piece between the gauge points is not to exceed 1½ inches; for material ·875 inch to ·375 inch in thickness, inclusive, the width is not to exeed 2 inches; for material less than ·375 inch in thickness the width is not to exceed 2½ inches. In other respects the test pieces are to conform to standard test piece A. (*See* P 312.)

Alternatively, a test piece having a gauge length of 2 inches, a width of ½ inch, a minimum parallel length of 2½ inches and a minimum radius at shoulder of 1 inch may be used.

Wherever practicable, the wrought surfaces are to be retained on two opposite sides of the test piece.

Straightening of Test Pieces

1618 Any straightening of test pieces which may be required is to be done cold, and the test pieces shall not receive further heat treatment or mechanical working before being tested except by machining to shape.

Chemical Composition

1619 Plates, bars and sections where of non-heat-treatable aluminium alloy are to have the following chemical composition:—

Copper	... not more than			0·10	per cent.
Magnesium	... ,,	,,	,,	5·50	,, ,,
,,	,,	less	,,	3·50	,, ,,
Iron	... ,,	more	,,	0·75	,, ,,
Silicon	... ,,	,,	,,	0·60	,, ,,
Manganese	... ,,	,,	,,	1·00	,, ,,
Chromium	... ,,	,,	,,	0·50	,, ,,
Zinc	... ,,	,,	,,	0·10	,, ,,
Aluminium	... The remainder.				

1620 Plates, bars and sections of heat-treatable aluminium alloy are to have the following chemical composition:—

Copper	... not more than			0·10	per cent.
Magnesium	... ,,	,,	,,	1·50	,, ,,
,,	,,	less	,,	0·40	,, ,,
Iron	... ,,	more	,,	0·60	,, ,,
Silicon	... ,,	,,	,,	1·30	,, ,,
,,	,,	less	,,	0·40	,, ,,
Manganese	... ,,	more	,,	1·00	,, ,,
,,	,,	less	,,	0·40	,, ,,
Chromium	... ,,	more	,,	0·50	,, ,,
Zinc	... ,,	,,	,,	0·03	,, ,,
Aluminium	... The remainder.				

Bars and Sections

1621 May be formed by extrusion, rolling or by drawing.

Number of Tensile Tests : Plates

1622 Plates from the same cast shall be grouped in thickness for testing as follows:—

1·00 inch and over in thickness.
·75 inch and less than 1·00 inch.
·50 inch and less than ·75 inch.
·18 inch and less than ·50 inch.

One tensile test is to be taken from each group.

Number of Tensile Tests : Bars and Sections

1623 Sections from the same cast of non-heat-treatable material shall be grouped in weight as follows:—

Less than 1 lb. per foot.
Between 1 lb. and 9 lb. per foot, inclusive.
More than 9 lb. per foot.

One tensile test is to be taken from each group.

1624 For sections from the same cast of heat-treatable alloy, the groups will be the heat-treatment batches as defined in P 1612. One tensile test is to be taken from each group.

Tensile Tests : Plates and Sections

1625 The 0·1 per cent proof stress is not to be less than 8 tons per square inch. The tensile breaking strength is not to be less than 17 tons per square inch, and the elongation, measured on a gauge length of 8 inches, is not to be less than 10 per cent.

Alternatively, if the elongation is measured on a gauge length of 2 inches it is not to be less than 12 per cent.

Occasional Attendance at Works

1626 Where the Surveyor is not in constant attendance at the works, the manufacturer may, with the written authority of the Society, comply with all the prescribed requirements and furnish the Surveyor with a certificate to the effect that the Society's Rules for the testing of aluminium alloys for shipbuilding purposes have been complied with in the case of material submitted for approval. The Surveyor is then to examine the works history sheets for the material submitted and, if these are in order, to take check tensile tests from the materials. If the material in a single cast is of uniform thickness, two tensile test pieces are to be selected; if of different thicknesses two tensile test pieces are to be selected from the range of thicknesses presented. The test pieces are to be selected by the Surveyor from the plates or sections themselves, and not from shearings previously detached from them, and, when marked by the Surveyor for testing, they are to be followed, as far as is practicable, through the different stages of preparation until the tests are completed. If more than one cast is represented each cast is to be tested.

1627 Where the tests are unsatisfactory, the whole of the material from the cast is to be rejected and the Surveyor is to see that the Society's brand is satisfactorily defaced.

Section 17

ALUMINIUM ALLOY RIVET BARS AND MANUFACTURED RIVETS

Testing of Material

1701 All material from which rivets are manufactured is to be tested.

1702 Tensile tests are to be selected in accordance with P 1623 or P 1624.

1703 The 0·1 per cent proof stress is not to be less than 6 tons per square inch. The tensile breaking strength is not to be less than 14 tons per square inch, and the elongation is not to be less than 15 per cent if measured on a gauge length of eight times the diameter of the test piece (test piece B) or alternatively, not less than 18 per cent if measured on a gauge length of four times the diameter of the test piece (test piece C).

Dump Test

1704 Test pieces of a length and diameter equal to the full diameter of the bars, preferably cut from the same bars as the tensile tests shall, when cold, withstand being compressed without cracking, until the diameter is increased to 1·6 times the original diameter.

Chemical Composition

1705 Rivet bars and manufactured rivets where of non-heat-treatable aluminium are to have the following chemical composition:—

Copper	... not more than		0·10	per cent.	
Magnesium	... ,,	less	,, 3·0	,,	,,
,,	... ,,	more	,, 4·0	,,	,,
Silicon	... ,,	,,	,, 0·60	,,	,,
Iron	... ,,	,,	,, 0·70	,,	,,
Manganese	... ,,	,,	,, 1·00	,,	,,
Chromium	... ,,	,,	,, 0·50	,,	,,
Aluminium	... The remainder.				

1706 Rivet bars and manufactured rivets where of heat-treatable material are to have the chemical composition as laid down in P 1620.

Manufactured Rivets: Heat Treatment and Testing

1707 Rivets of non-heat-treatable alloys are to be supplied in the annealed condition.

Rivets of heat-treatable alloy are to be delivered to the shipyard in the heat-treated condition specified. If, however, suitable facilities are available, then with the concurrence of the rivet manufacturer, the heat treatment may be carried out in the shipyard.

1708 Rivets selected by the Surveyor from bulk are to withstand the tests described in 1709.

1709 Test pieces, cut from the shanks of manufactured rivets, of a length and diameter equal to the full diameter of the shank, shall, when cold, withstand being compressed in an axial direction, without cracking, until the diameter is increased to 1·6 times the original diameter.

Section 18

WELDING OF ALUMINIUM ALLOYS

General

1801 For general requirements where welding is employed, *see* D 3127.

Processes

1802 The following welding processes are to be adopted in the welding of non-heat-treatable aluminium alloys:—

Inert gas metal arc welding.
Inert gas tungsten arc welding.
Other processes are to be submitted for approval.

Filler Wire

1803 The chemical composition of filler wire used in welding is to conform to the following requirements:—

Copper	... not more than		0·10	per cent.	
Magnesium	... ,,	,,	,, 5·50	,,	,,
,,	... ,,	less	,, 4·50	,,	,,
Iron	... ,,	more	,, 0·70	,,	,,
Silicon	... ,,	,,	,, 0·60	,,	,,
Manganese	... ,,	,,	,, 1·00	,,	,,
Chromium	... ,,	,,	,, 0·50	,,	,,
Aluminium	... The remainder.				

26th January, 1961

APPENDIX

STEEL MANUFACTURERS

The following establishments have complied with the requirements for quality and testing of steel and have been recognised by the Committee.

Firms in Great Britain and Ireland

Allen, Edgar, & Co., Ltd., Imperial Steel Works, Tinsley, Sheffield. (*Castings.*)
Alston Foundry Co., Ltd., Nent Force Foundry, Alston, Cumberland. (*Small castings.*)
Andrews Toledo, Ltd., Toledo Steel Works, Neepsend, Sheffield. (*Ingots, billets and bars.*)
Appleby-Frodingham Steel Co., Branch of the United Steel Companies, Ltd., Scunthorpe, Lincs.,
Appleby Works. (*Plates and blooms.*)
Frodingham Works. (*Sections, bars and blooms.*)
Armstrong Whitworth (Metal Industries) Ltd., Western Road Works, Jarrow. (*Castings.*)
Atlas Steel Foundry and Engineering Co., Ltd., The, Armadale, West Lothian. (*Castings.*)
Babcock & Wilcox, Ltd., Renfrew. (*Small castings.*)
Baird, Archibald, & Sons, Ltd., Hamilton, Lanarkshire. (*Castings.*)
Bairds & Scottish Steel, Ltd., Coatbridge, Lanarkshire,
Northburn Works. (*Ingots, billets, sections and bars.*)
Waverley Works. (*Sections and bars.*)
Victoria Works. (*Sections and bars.*)
Woodside Works. (*Sheets and strips.*)
Coats Works. (*Sections and bars.*)
Rochsolloch Works. (*Sections and bars.*)
Baker, J., & Bessemer, Ltd., Kilnhurst Steel Works, near Rotherham. (*Ingots and forgings.*)
Baker, W. A., & Co., Ltd., Westgate Works, Newport, Mon. (*Castings.*)
Baker Perkins Ltd., Peterborough. (*Small castings.*)
Barrow Steel Works, Ltd., Barrow-in-Furness, Lancashire. (*Ingots, billets, bars and sections.*)
Beardmore, William, & Co., Ltd., Parkhead, Glasgow. (*Castings, ingots, forgings, billets and blooms.*)
Blackett, Hutton & Co., Ltd., Cleveland Steel Foundry, Guisborough, Yorkshire. (*Castings.*)
Blair, George, & Co., Ltd., Armond Carr Works, Tow Law, Co. Durham. (*Castings.*)
Bond's Foundry Co., Tow Law, Co. Durham. (*Small castings.*)
Bonnington Castings, Ltd., Leith. (*Small castings.*)
British Rolling Mills, Ltd., Brymill Works, Tipton, Staffs. (*Cold drawn bright bars.*)
Briton Ferry Steel Co., Ltd., Briton Ferry, Neath, Glamorgan. (*Billets.*)
Brockhouse Castings, Ltd., Wednesfield, Wolverhampton. (*Small castings.*)
Brown Bayley Steels, Ltd., Sheffield. (*Ingots, forgings and bars.*)
Brown, The David, Industries, Ltd., (Foundry Division), Penistone, Yorks. (*Castings.*)
Brown, Lenox & Co., Ltd., Pontypridd. (*Castings.*)
Brymbo Steel Works, Branch of G.K.N. Steel Co., Ltd., Brymbo, Wrexham, North Wales. (*Electric steel for forging and re-rolling.*)
Bynea Steel Works, Ltd., Llanelly, Carmarthenshire. (*Billets and sections.*)
Carntyne Steel Castings Co., Ltd., Moorpark, Renfrew. (*Castings.*)
Catton & Co., Ltd., Yorkshire Steel Foundry, Hunslet, Leeds. (*Castings.*)
Clyde Alloy Steel Co., Ltd.,
Craigneuk Works, Flemington, Motherwell. (*Castings.*)
Hallside Works, Newton, Glasgow. (*Castings and Sections.*)
Coghlan Forge & Rolling Mills, Ltd., and Coghlan Bright Steel, Ltd., Hunslet Forge, Leeds. (*Rolling mills for bars ; forgings.*)

Colvilles Ltd.,
- Blochairn Works, Glasgow. (*Plates.*)
- Clydebridge Steel Works, Cambuslang, near Glasgow. (*Plates.*)
- Dalzell Steel and Iron Works, Motherwell, Lanarkshire. (*Plates, sections, bars and blooms.*)
- Glengarnock Steel Works, Glengarnock, Ayrshire. (*Sections and bars.*)
- Ravenscraig Works, Ravenscraig, Lanarkshire. (*Ingots.*)

Consett Iron Co., Ltd., Blackhill, Durham.

Consett Iron Co., Ltd., (Jarrow Mill), Blackett Street, Jarrow-on-Tyne. (*Rolling mills for sections and rounds.*)

Crofts (Engineers), Ltd., Thornbury, Bradford. (*Castings.*)

Cruikshank & Co., Ltd., Denny Iron Works, Denny, Stirlingshire. (*Small castings.*)

Curran Steels Ltd., Cardiff. (*Ingots and castings.*)

Darlington Forge Ltd., Albert Hill, Darlington. (*Castings, ingots and forgings.*)

Darlington & Simpson, Rolling Mills Ltd., Darlington. (*Rolling mills for small sections and bars.*)

Davy & United Roll Foundry, Ltd., Empire Works, Haverton Hill, Billingham, Co. Durham. (*Castings.*)

Dorman, Long (Steel) Ltd.,
- Britannia Works, Middlesbrough. (*Rolling mills for sections and bars.*)
- Cleveland Works, South Bank, Middlesbrough. (*Sections and bars.*)
- Lackenby Works, Middlesbrough. (*Ingots, billets, sections, bars and strips.*)
- Redcar Works, Redcar. (*Plates.*)

English Steel Casting Corporation, Ltd., Grimesthorpe Works, Sheffield. (*Ingots and castings.*)

English Steel Forge & Engineering Corporation Ltd.,
English Steel Rolling Mills Corporation Ltd.,
- North St. Works, Openshaw, Manchester. (*Forgings, bars, plates up to $\frac{1}{2}$ inch in thickness.*)
- River Don Works, Sheffield. (*Forgings, plates, billets and bars.*)
- Stevenson Road Works, Sheffield. (*Ingots, blooms, billets and bars.*)

Etna Iron and Steel Co., Ltd., Motherwell, Lanarkshire. (*Rolling mills for sections and bars.*)

Firth, Thos. & John Brown, Ltd.,
- Atlas Works, Sheffield. (*Ingots, forgings, rolled bars and billets.*)
- Scunthorpe Works, Scunthorpe, Lincs. (*Castings.*)

Firth Vickers Stainless Steels, Ltd., Sheffield. (*Rolling mills for plates, bars and sections; also castings.*)

Fox, Samuel, & Co., Ltd., Stocksbridge Works, near Sheffield. (*Ingots.*)

Glanmorfa Ltd., Llanelly. (*Castings.*)

Guest, Keen & Nettlefolds (South Wales), Ltd., Cardiff.
- Castle Works. (*Rolling mills for bars and strips.*)
- Tremorfa Works. (*Rolling mills for bars and sections.*)

Guest Keen Iron & Steel Co., Ltd., East Moors, Cardiff. (*Ingots, blooms and billets; sections and bars.*)

Hadfields, Ltd., East Hecla Works, Sheffield. (*Ingots, blooms, billets, forgings, bars, special sections and castings.*)

Halesowen Steel Co., Ltd.; The, Halesowen, near Birmingham. (*Cold drawn bright bars.*)

Hamilton, A., & Sons, Ltd., Victoria Foundry, East Moors, Cardiff. (*Small castings.*)

Head, Wrightson Steel Foundries, Ltd.,
- Light Pipe Hall Road, Stockton-on-Tees. (*Castings.*)
- Teesdale Iron Works, Thornaby-on-Tees. (*Castings.*)

Hopkinsons, Ltd., Britannia Works, Huddersfield, Yorkshire. (*Castings.*)

Hyde, Robert & Son, Ltd.,
- Clarendon Works, Chesterfield. (*Small castings.*)
- North Stafford Steel Works, Stoke-on-Trent. (*Small castings.*)

Jackson, Elphick & Co., Ltd., Larkhall, Lanarkshire. (*Castings.*)

Jessop-Saville, Ltd., Brightside Works, Sheffield. (*Ingots, blooms, bars, forgings and castings.*)

Jopling, E., & Sons, Pallion, Sunderland. (*Castings.*)

Kirkstall Forge Engineering, Ltd., Leeds. (*Rolling mills for bars, forgings and heavy drop forgings.*)

K. & L. Steelfounders & Engineers Limited, Letchworth, Hertfordshire. (*Ingots and castings.*)

Lake & Elliot, Ltd., Engineers and Founders, Braintree, Essex. (*Small castings.*)
Lanarkshire Steel Co., Ltd., Motherwell, Lanarkshire. (*Sections.*)
Lancashire Steel Manufacturing Co., Ltd.,
Irlam, Manchester. (*Billets, bars, sections and castings.*)
Pearson & Knowles Works, Warrington, Lancs. (*Rolling mills for sections and bars.*)
Leyland Motors, Ltd., Farington Foundries, Leyland. (*Castings.*)
Lilleshall Co., Ltd., St. George's, near Oakengates, Shropshire. (*Rolling mills for sections and bars.*)
Llanelly Steel Co. (1907) Ltd., Llanelly Steel Works, Llanelly. (*Billets and bars.*)
Lloyd, F. H., & Co., Ltd., James Bridge, near Wednesbury, Staffordshire. (*Ingots and castings.*)
Lloyds (Burton) Ltd., Wellington Works, Burton-on-Trent, Derbyshire. (*Ingots and castings.*)
Lysaght's, John, Scunthorpe Works Ltd., Scunthorpe, Lincs. (*Ingots, billets and slabs.*)
Martins (Dundyvan), Ltd., Coatbridge, Lanarkshire. (*Rolling mills for sections.*)
Mills, Exors. of James, Ltd., Bredbury Steel Works & Rolling Mills, near Stockport. (*Rolling mills for bars.*)
Monks, Hall & Co., Ltd., Warrington. (*Rolling mills for bars.*)
National Steel Foundry (1914), Ltd., The, Kirkland Works, Leven, Fifeshire. (*Castings.*)
North British Steel Foundry, Ltd., The, Balbardie Steel Works, Bathgate. (*Small castings.*)
Osborn, Samuel, & Co., Ltd., Clyde Steel Works, Sheffield. (*Castings.*)
Park Gate Iron & Steel Co., Ltd., Rotherham, Yorkshire.
Parker Foundry (1929) Ltd., "Tropenas" Steel Works, Derby. (*Small castings.*)
Patent Shaft Steel Works, Ltd., Wednesbury, Staffordshire.
Raine & Co., Ltd., Delta Iron & Steel Works, Derwenthaugh, Newcastle-on-Tyne. (*Rolling mills for sections and bars.*)
Redheugh Iron & Steel Co. (1936), Ltd., Teams, Gateshead-on-Tyne. (*Rolling mills.*)
Renton & Fisher, Ltd., Hopetoun Steel Works, Bathgate. (*Castings.*)
Robertson, Wm., Ltd., Latchford, Warrington. (*Cold drawn bright bars.*)
Round Oak Steel Works, Ltd., Brierley Hill, Staffordshire. (*Ingots, blooms, billets, bars and sections.*)
Ryder Brothers, Ltd. (Beehive Steel Foundry), Bolton. (*Small castings.*)
Sanderson Brothers & Newbould Limited, Sheffield. (*Ingots, billets and bars.*)
Shaw, W., & Co., Ltd., Wellington Cast Steel Foundry, Middlesbrough. (*Castings.*)
Shelton Iron & Steel, Ltd., Stoke-on-Trent. (*Ingots, billets, bars and sections.*)
Skinningrove Iron Co., Ltd., Skinningrove Iron Works, Saltburn-by-the-Sea. (*Sections and bars.*)
Smith & McLean, Ltd.,
Gartcosh Works, Gartcosh, Lanarkshire. (*Thin plates.*)
Milnwood Works, Mossend, Lanarkshire. (*Thin plate and light sections.*)
South Durham Steel & Iron Co., Ltd.,
West Hartlepool. (*Plates.*)
Cargo Fleet Ironworks, Middlesbrough. (*Sections and bars.*)
Spartan Steel and Alloys Ltd., Spartan Works, Birmingham 6. (*Ingots.*)
Spear & Jackson, Ltd., Sheffield. (*Ingots and billets.*)
Springfield Steel Co., Ltd., 1323, London Road, Glasgow. (*Castings.*)
Steel Company of Wales, Ltd.,
Abbey Works, Port Talbot. (*Ingots, plates and strips.*)
Margam Works, Port Talbot. (*Ingots.*)
Port Talbot Works, Port Talbot. (*Ingots.*)
Steel, Peech & Tozer, Rotherham, Branch of The United Steel Companies Ltd. (*Ingots, blooms, forgings, rivet and stay bars.*)
Stewarts & Lloyds, Ltd.,
Bilston Iron & Steel Works, Bilston, Staffordshire. (*Tube ingots, billets and bars.*)
Clydesdale Steel and Tube Works, Bellshill, Lanarkshire. (*Ingots.*)
Corby Works, Corby, Northants. (*Ingots, billets, slabs and strips.*)
Tollcross Foundry, Tollcross, Glasgow. (*Castings.*)
Summers, John, & Sons Ltd., Hawarden Bridge Steel Works, Shotton, Chester. (*Slabs for plates.*)

Summersons Foundries, Ltd., Darlington. (*Small castings.*)
Taylor Bros. & Co., Ltd., Trafford Park Steel Works, Manchester. (*Ingots.*)
Thomas, Richard, & Baldwins, Ltd.,
Pontardawe Works, near Swansea. (*Ingots, billets and bars.*)
Redbourne Works, Scunthorpe. (*Ingots, billets, bars and slabs.*)
Vickers-Armstrongs (Engineers) Ltd.,
Barrow-in-Furness. (*Castings and forgings.*)
Elswick Works, Elswick, Northumberland. (*Castings.*)
Washington Steel Foundries, Ltd., Washington Station S.O., Co. Durham. (*Castings.*)
West Lothian Steel Foundry Co., Ltd., Harthill Works, Armadale, West Lothian. (*Small castings.*)
Whitehead Iron & Steel Co., Ltd., Courtybella Works, Newport, Mon. (*Rolling mills for strips, bars and sections.*)
Whitehead Thomas Bar and Strip Co., Ltd., Redbourne Works, Scunthorpe, Lincs. (*Rolling mills for bars and strips.*)
Williams, John, & Co. (Wishaw), 1922, Ltd., Excelsior Iron & Steel Works, Craigneuk, Motherwell, Lanarkshire. (*Rolling mills for thin plates.*)
Wilson's Foundry & Engineering Co., Ltd., Bishop Auckland, Co. Durham. (*Castings.*)
Wolsingham Steel Co., Ltd., Wolsingham, Co. Durham. (*Castings and forgings.*)
Workington Iron & Steel Co., Workington, Cumberland. (*Ingots, blooms, billets, slabs and rolled sections in electric steel.*)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ALPHABETICALLY ARRANGED)

Note: The place of residence of the Surveyor giving attendance at each works is shown in parentheses.

A.1. Iron & Steel Foundry, Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*) (GENOA.)

Aceros del Zarzo S.A. (Adeza), Cabanas, Puentedeume (La Coruna), Spain. (*Ingots and small castings.*) (VIGO.)

Acieries du Furan, St. Etienne (Loire), France. (*Electric steel castings.*) (MARSEILLES.)

"Acieroy", Aciéries et Fonderies du Doubs, Société Anonyme, Sainte-Suzanne, near Montbéliard (Doubs), France. (*Small electric steel castings.*) (MARSEILLES.)

Acos Villares S.A. Sao Caetano do Sul, Sao Paulo, Brazil. (*Castings, forgings, billets and bars.*) (RIO DE JANEIRO.)

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*) (ABO.)

Aichi Steel Works, Ltd.,
Chita Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)
Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*) (KOBE.)

Alco Products, Inc., Latrobe, Pa., U.S.A. (*Ingots and forgings.*) (PITTSBURGH, PA.)

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars, angles and plates.*) (TORONTO.)

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Allard, Usines & Aciéries, Société Anonyme, Turnhout, Belgium. (*Small castings.*) (ANTWERP.)

Alves, Alfredo, & Cia. (Filhos), Amadora, Portugal. (*Castings.*) (LISBON.)

Amagasaki Iron & Steel Mfg. Co., Ltd.,
Kure Steel Works, Kure, Japan. (*Ingots and castings.*) (SHIMONOSEKI.)
Steel Plant, Amagasaki, Japan. (*Ingots, plates, sections and bars.*) (KOBE.)

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*) (CLEVELAND, O.)

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*) (MALMÖ.)

Ando Iron Works Co., Ltd., Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Ansaldo S.p.A., Stabilimento Fonderia di Ghisa e Metalli, Genova-Pegli, Italy. (*Forgings.*) (GENOA.)

"ARBED," Aciéries Réunies de Burbach-eich-Dudelange,
Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*) (ANTWERP.)
Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*) (ANTWERP.)
Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*) (ANTWERP.)
Division de Burbach, Sarrebruck,
Burbach Works. (*Ingots, billets and sections.*) (SAARBRÜCKEN-SAAR.)
Hostenbach Works. (*Plates.*) (SAARBRÜCKEN-SAAR.)

Astilleros y Talleres del Noroeste S.A., El Ferrol del Caudillo, Spain. (*Small forgings.*) (GIJON.)

Atlantic Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Atlas Steels, Ltd., Welland, Ontario, Canada. (*Ingots and bars.*) (TORONTO.)

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dome, France. (*Ingots, rolled bars and forgings.*) (MARSEILLES.)

August Thyssen-Hütte, A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections and bars.*) (DUSSELDORF.)

Australian Iron & Steel, Pty., Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*) (SYDNEY.)

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*) (STOCKHOLM.)

Azuma Steel Works, Ltd.,
Azuma Plant, Tokyo, Japan. (*Ingots for plate.*) (YOKOHAMA.)
Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*) (YOKOHAMA.)

Babcock & Wilcox, Sociedad Espanola de Construcciones. *Head Office:* Calle Ercilla 1, Bilbao, Spain.
Works: Galindo-San Salvador Del Valle, Vizcaya, Spain. (*Castings, ingots and forgings.*) (BILBAO.)

Bakker, N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*) (ROTTERDAM.)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*) (BILBAO.)

Bergische Stahlindustrie K. G., Remscheid, Germany. (*Castings.*) (DUSSELDORF.)

Bertoli fu Rodolfo, Società Anonima Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*) (TRIESTE.)

Bethlehem Pacific Coast Steel Corporation,
Los Angeles 54, Cal., U.S.A. (*Round bars.*) (LOS ANGELES.)
Seattle, Wash., U.S.A. (*Sections and bars.*) (SEATTLE.)
South San Francisco, Cal., U.S.A. (*Ingots, small sections and bars.*) (SAN FRANCISCO.)

Bethlehem Steel Co.,
Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*) (PHILADELPHIA.)
Buffalo, N.Y., U.S.A. (CLEVELAND, O.)
Johnstown Plant, Johnstown, Pa., U.S.A. (PITTSBURGH.)
Lebanon, Pa., U.S.A. (*Rolling mills for bars.*) (PHILADELPHIA.)
Sparrows Point, Md., U.S.A. (*Plates.*) (BALTIMORE.)
Steelton, Pa., U.S.A. (*Forgings and castings.*) (PHILADELPHIA.)

Bhartia Electric Steel Co., Ltd., Calcutta, India. (*Castings.*) (CALCUTTA).

Birdsboro Corporation, Birdsboro, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Ingots and forgings*). (GOTHENBURG.)

Blanc-Misseron, Société Française des Aciéries de, Quievrechain, Nord, France. (*Ingots and castings.*) (VALENCIENNES.)

Bochumer Verein für Guss-stahlfabrikation A.G., Bochum, Germany. (*Ingots, forgings, castings and bars.*) (DUSSELDORF.)

Boel, Usines Gustave, Soc. An., La Louvière, Belgium. (*Ingots, forgings, castings, plates and bars.*) (ANTWERP.)

Bofors, Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*) (GOTHENBURG.)

Böhler, Gebr. & Co., Aktiengesellschaft, Vienna, Austria.
Works: Kapfenberg, Styria. (*Ingots, castings, forgings, bars and plates.*) (VIENNA.)
Works: Bruckbach, Low Austria. (*Rolling mills for sections and bars.*) (VIENNA.)

Bolzaneto, Acciaieria e Ferriera di, Genoa, Italy. *Works:* Genoa-Bolzaneto. (*Plates, sections and bars.*) (GENOA.)

Bolzano, Società per Azioni Acciaierie di, Bolzano, Italy. (*Ingots, billets, bars and forgings.*) (VENICE.)

Boom, Travaux Métalliques de, Société Anonyme, Boom, Belgium. (*Small castings.*) (ANTWERP.)

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*) (BERLIN.)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*) (STOCKHOLM.)

Bradford, Kendall, Ltd., Alexandria, Sydney, N.S.W. (*Castings.*) (SYDNEY, N.S.W.)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves, Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*) (RIO DE JANEIRO.)

Breda Fucine S.p.A., Sesto San Giovanni, Milan, Italy. (*Castings and forgings.*) (MILAN.)

Breda Siderurgica Società per Azioni, Sesto San Giovanni, Milan, Italy. (*Ingots and sections.*) (MILAN.)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*) (COLOGNE.)

Brescia, Acciaieria e Tubificio di, Società Anonima, Brescia, Italy. (*Ingots, sections and bars, castings, weldless drawn or water gas welded tubular material.*) (MILAN.)

Broken Hill Proprietary Co., Ltd.,
Rolling Mill, Kwinana W. Australia. (*Small bars and sections.*) (FREMANTLE.)
Iron & Steel Works, Newcastle, N.S.W. (*Plates, bars, sections and castings.*) (NEWCASTLE, N.S.W.)
Steel Foundry, Whyalla, S. Australia. (*Castings.*) (WHYALLA.)

Brugeoise et Nivelles, Société Anonyme La, St. Michel-lez-Bruges, Belgium. (*Castings.*) (ANTWERP.)

Burlington Steel Co., Ltd., Hamilton, Ontario, Canada. (*Small sections and bars.*) (TORONTO.)

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

Burn & Co., Ltd., Howrah, India. (*Small castings.*) (CALCUTTA.)

Byers Company, A.M., Admin. Office:- Clark Building, Pittsburg 22, Pa., U.S.A.
Economy, Pa., (*Plates, bars and ingots for forging.*) (PITTSBURGH.)

Caleotto, Acciaieria e Ferriera del, S.p.A., Lecco, Italy. (*Ingots, castings, bars, small sections and small forgings.*) (MILAN.)

Canada Foundries & Forging, Ltd., Welland, Ontario, Canada. (*Forgings.*) (TORONTO.)

Canadian Steel Foundries Ltd., Longue Pointe, Montreal, P.Q., Canada. (*Castings.*) (MONTREAL.)

Canadian Sumner Iron Works Ltd., Vancouver, B.C. (*Small castings.*) (VANCOUVER.)

Canadian Tube & Steel Products, Ltd., 5765, Hamilton Street, Montreal, P.Q., Canada. (*Angles, bars and rivets.*) (MONTREAL.)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*) (MONTREAL.)

Cantieri Del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*) (GENOA.)

Cantieri Navali Riuniti. *Head Office* : Genoa. *Works:* Cantiere Navale ed Officine Meccaniche di Ancona. (*Small castings.*) (MILAN.)

Ceretti, Pietro Maria, S.p.A., Ferriera Dell'Ossola-Villadossola, Italy. (*Castings.*) (MILAN.)

Charleroi, Société Anonyme de la Fabrique de Fer de, Charleroi, Belgium. (*Ingots and plates.*) (ANTWERP.)

Chiers, Société des Hauts-Forneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, sections and bars.*) (VALENCIENNES.)

Christiania Spigerverk, Oslo, Norway. (*Ingots and bars, also rivet bars.*) (OSLO.)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*) (ANTWERP.)

Cockerill-Ougrée, Société Anonyme, Seraing, Belgium.
Works: Grivegnée. (*Ingots and plates.*) (ANTWERP.)
Works: Ougrée. (ANTWERP.)
Works: Seraing. (ANTWERP.)

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*) (CLEVELAND, O.)

Columbia-Geneva Steel Division, United States Steel Corporation,
Torrance Works, Torrance, Calif., U.S.A. (*Round bars and sections.*) (LOS ANGELES.)
Geneva Works, Provo, Utah, U.S.A. (*Plates.*) (LOS ANGELES.)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*) (NEWCASTLE, N.S.W.)

Compagnie des Ateliers et Forges de la Loire,
Usine des Dunes, Malo les Bains (Nord), France. (*Ingots, billets, blooms, bars and forgings.*) (VALENCIENNES.)
Usines de l'Ondaine, Firmigny (Loire), France. (*Ingots, billets, blooms, bars, castings and forgings.*) (MARSEILLES.)
Usines de l'Ondaine, Unieux (Loire), France. (*Forgings.*) (MARSEILLES.)
Usines de St. Chamond, St. Chamond (Loire), France. (*Forgings and plates.*) (MARSEILLES.)
Usines de St. Etienne, St. Etienne (Loire), France. (*Plates.*) (LYONS.)
Usines des Forges de l'Adour, Le Boucau, France. (*Plates and sections.*) (BORDEAUX.)

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*) (ANTWERP.)

Companhia Siderurgica Nacional, Volta Redonda, Estado do Rio de Janeiro, Brazil. (*Plates and sections.*) (RIO DE JANEIRO.)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*) (BILBAO.)

Construcciones Agricolas, Sociedad Anonima de, (S.A.C.A.), Sevilla, Spain. (*Castings.*) (CADIZ.)

Creusot, Société des Forges et Ateliers du, (S.F.A.C.), Usines Schneider, Le Creusot, France. (*Ingots, forgings, castings, plates and sections.*) (MARSEILLES.)

Crucible Steel Castings Co., Lansdowne, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Crucible Steel Company of America, 4, Gateway Center, P.O. Box 88, Pittsburgh 30, Pa., U.S.A.
Midland Plant, Midland, Pa. (*Ingots, slabs, billets, universal mill plates, hot rolled and cold drawn bars.*) (PITTSBURGH.)

Crucible Steel Company of Canada, Ltd., Sorel, P.Q., Canada. (*Castings.*) (MONTREAL.)

Crucible Vanzetti S.p.A., Acciaierie, Milan, Italy. (*Castings.*) (MILAN.)

Daido Steel Co., Ltd.,
Hoshizaki Works, Nagoya, Japan. (*Ingots and bars.*) (KOBE.)
Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Dalmine S.p.A. *Head Office:* Milan, Italy.
Dalmine Costa Volpino, Bergamo. (*Seamless tubes.*) (MILAN.)
Dalmine Works, Bergamo. (*Ingots and seamless tubes.*) (MILAN.)

Danske, (Det), Staalvalsevaerk A/S, Frederiksvaerk, Denmark. (*Plates, sections and bars.*) (COPENHAGEN.)

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

de Roll, Société des Usines de Louis, Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*) (WINTERTHUR.)

De Wendel et Cie., S/A., Hayange, Moselle, France.
Usine de Fenderié. (*Plates.*) (SAAR.)
Usine de St. Jacques. (*Sections.*) (SAAR.)

Degerfors Jernverks Aktiebolag, Degerfors, Sweden. (*Ingots, plates, sections and bars.*) (GOTHENBURG.)

Deusto, Sociedad Anonima Talleres de, Deusto, Bilbao, Spain. (*Castings.*) (BILBAO.)

Deutsche Edelstahlwerke A.G., Krefeld, Germany. (*Ingots, castings, forgings and rolled materials.*) (DUSSELDORF.)

Deutsche Gerätebau G.m.b.H., Werk Stahl u., Eisengiesserei Schubeis, Schwelm, Germany. (*Castings.*) (DORTMUND.)

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*) (AMSTERDAM.)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*) (SAARBRÜCKEN-SAAR.)

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein, Germany. (*Castings.*) (MANNHEIM.)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Dominion Foundries & Steel Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*) (TORONTO.)

Dominion Iron & Steel, Ltd., Sydney Works, Sydney, Nova Scotia. (*Ingots, billets and sections.*) (HALIFAX, N.S.)

Dominion Steel & Coal Corporation Ltd., Trenton Works, Trenton, N.S., Canada. (*Forgings.*) (HALIFAX, N.S.)

Donegal Steel Foundry Company, 601, East Market Street, Marietta, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Dortmund - Hoerder Hüttenunion, A.G., Dortmund, Germany.
Dortmund-Hoerde Works. (*Ingots, plates, sections, bars, forgings and castings.*) (DORTMUND.)
Dortmund Works. (*Bars, sections and forgings.*) (DORTMUND.)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen, Norway. (*Small castings.*) (OSLO.)

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets and small sections.*) (VEREENIGING.)

Duro-Felguera, Sociedad Metalúrgica, La Felguera, Asturias, Spain. (*Ingots, billets, castings, plates and sections.*) (GIJON.)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars, small forgings and ingots.*) (BILBAO.)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms and forgings.*) (BILBAO.)

Eisen-und Stahlgiesserei Gebrüder Decker, Nürnberg, Germany. (*Electric steel castings.*) (AUGSBURG.)

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*) (HANOVER.)

Eisenwerk Geweke, R. & C. R. Lange K.G., Hagen-Haspe, Germany. (*Electric steel castings.*) (DORTMUND.)

Eisenwerk Rödinghausen K.G., Lendringsen Krs., Iserlohn, Germany. (*Castings.*) (DORTMUND.)

Eisenwerke Mülheim - Meiderich Aktiengesellschaft, Mülheim-Ruhr, Germany. (*Castings.*) (DUSSELDORF.)

"ELCANO", Empresa Nacional, Factoria de Manises, Valencia, Spain. (*Castings and forgings.*) (VALENCIA.)

Ellerbrock, Hans, Stahlgiesserei und Maschinenfabrik, Hamburg, Germany. (*Castings.*) (HAMBURG.)

Empresa Nacional Bazan, El Ferrol del Caudillo, Spain. (*Castings.*) (VIGO.)

Empresa Nacional Siderurgica, S.A., (ENSIDESA), Avilés, Spain. (*Ingots, slabs and billets for re-rolling.*) (GIJON.)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*) (CLEVELAND, O.)

Eschweiler Bergwerks-Verein Hüttenbetriebe, Eschweiler-Aue, Germany. (*Ingots and seamless tubes.*) (DUSSELDORF.)

Española de Construccion Naval, Sociedad.

Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*) (BILBAO.)

Sestao, near Bilbao, Spain. (*Small castings, ingots and forgings.*) (BILBAO.)

San Carlos Factory, San Fernando, Cadiz, Spain. (*Forgings and castings.*) (CADIZ.)

l'Est, Société des Aciers Fins de, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheets.*) (SAAR.)

Euskalduna, Compañia, Talleres de Elorrietta, Bilbao, Spain. (*Castings.*) (BILBAO.)

Fabrica de Mieres, Mieres, Asturias, N. Spain. (*Sections, bars and plates up to 15 mm. in thickness.*) (GIJON.)

Fabrica Italiana Tubi, Società Anonima, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*) (GENOA.)

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Brukskoncernen.)

Works : Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*) (STOCKHOLM.)

Works : Forsbacka. (*Blooms, billets, forged and rolled bars.*) (STOCKHOLM.)

Works : Horndal. (*Bars and sections.*) (STOCKHOLM.)

Works : Osterbybruk. (*Castings, forgings and rolling mill for bars.*) (STOCKHOLM.)

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia, Italy. (*Small castings.*) (LA SPEZIA.)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works :* Milan, Italy. (*Weldless rolled or drawn tubes.*) (MILAN.)

"Concordia." *Works :* Sesto San Giovanni. (*Rolling mills for plates.*) (MILAN.)

"Unione." *Works :* Sesto San Giovanni. (*Ingots, sections, bars, forgings and castings.*) (MILAN.)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*) (CLEVELAND, O.)

Ferry-Capitain & Cie., Société, Bussy, près Joinville, Haute-Marne, France. (*Electric steel castings.*) (PARIS.)

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections, also seamless and welded tubes.*) (GENOA.)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings.*) (GENOA.)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*) (CLEVELAND, O.)

Fischer, Société Anonyme des Aciéries ci-devant Georges, Schaffhouse, Switzerland. (*Castings.*) (WINTERTHUR.)

Fiskars Oy., A.B.

Aminnefors Works, Aminnefors, Finland. (*Ingots, billets, bars and sections.*) (ÅBO.)

Inha Works, Inha, Finland. (*Ingots and bars.*) (ÅBO.)

Fives-Lille-Cail, Société de,

Usine de Fives, Lille (Nord), France. (*Forgings.*) (VALENCIENNES.)

Usine de Denain, Denain (Nord), France. (*Castings, ingots, forgings, blooms, bars and sheets.*) (VALENCIENNES.)

Fonderia Acciaieria Giovanni Mandelli, Turin, Italy. (*Small castings.*) (GENOA.)

Frichs A/S, Aarhus, Denmark. (*Castings.*) (COPENHAGEN.)

Fuji Iron & Steel Co., Ltd.

Works : Hirohata, Himeji City, Japan. (*Ingots, billets and plates.*) (KOBE.)

Works : Kamaishi, Japan. (*Sections and bars.*) (YOKOHAMA.)

Works : Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*) (YOKOHAMA.)

Works : Muroran, Hokkaido, Japan. (*Billets, sections and bars.*) (YOKOHAMA.)

Fujinagata Shipbuilding Co., Ltd., Osaka, Japan. (*Castings and forgings.*) (KOBE.)

Fundiciones Echevarria S.A., Beasain, Guipuzcoa, Spain. (*Ingots and small rolled bars.*) (BILBAO.)

Fundiciones Escorsa S.A., Pi y Margall, 2- Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*) (BARCELONA.)

Fundiciones Ituarte S.A., Bilbao, Spain. (*Small castings.*) (BILBAO.)

Ganz-Mavag Mozdony Vagon es Gepgyar, Budapest, Hungary. (*Castings and forgings.*) (VIENNA.)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

General Steel Castings Corporation, Eddystone, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Gennevilliers, Aciéries de, Gennevilliers, Seine, France. (*Castings.*) (PARIS.)

Gilson, Société Anonyme des Usines, Belgium.
- La Croyère (Bois d'Haine). (*Ingots, blooms, sections, rivet bars and forgings.*) (ANTWERP.)
- Division "Baume", Haine-St.-Pierre. (*Ingots, bars and sections.*) (ANTWERP.)

Go Iron Works, Ltd., Ogaki Works, Ogaki, Japan. (*Small castings.*) (KOBE.)

Gorizia, Società Anonima Fonderie Officine di, Gorizia, Italy. (*Small castings.*) (TRIESTE.)

Granite City Steel Co., Granite City, Ill., U.S.A. (CLEVELAND, O.)

Great Lakes Steel Corporation, Division of National Steel Corporation, Ecorse, Detroit 29, Michigan, U.S.A. (*Ingots, billets, bars, slabs, plate, blooms, sheet and coiled strip.*) (CLEVELAND.)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza, Italy. (*Castings, bars, sections and forgings.*) (VENICE.)

Guérigny, Forges Nationales de la Chaussade à Nièvre, France. (*Ingots, bars and forgings.*) (MARSEILLES.)

Gussstahlwerk Carl Bönnhoff, Wetter/Ruhr, Germany. (*Castings.*) (DORTMUND.)

Gussstahlwerk Gelsenkirchen A.G., Gelsenkirchen, Germany. (*Castings.*) (DUSSELDORF.)

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*) (DUSSELDORF.)

Gussstahlwerk Risch K.G., Bergisch-Gladbach, Germany. (*Electric steel castings.*) (DUSSELDORF.)

Gussstahlwerk Witten A.G., Witten (Ruhr), Germany. (*Ingots, billets, sections, bars and forgings.*) (DORTMUND.)

Gussstahlwerk Wittman A.G., Hagen-Haspe, Germany. (*Castings.*) (DORTMUND.)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*) (DUSSELDORF.)

Hachette & Driout, S.A. des Anciens Etablissements, St. Dizier, Hte. Marne, France. (*Castings.*) (VALENCIENNES.)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*) (SYDNEY.)

Hadfields (W.A.) 1934 Ltd., Perth, Western Australia. (*Castings.*) (FREMANTLE.)

HADIR, Société des Haut-Fourneaux et Aciéries de Differdange-St.Ingbert-Rumelange, Differdange Works, Luxembourg. (*Sections and bars.*) (ANTWERP.)

Hahn'sche Werke, A.G., Duisburg-Grossenbaum, Germany. (*Bars and electric resistance welded tubes.*) (DUSSELDORF.)

Hainaut-Sambre, Société Métallurgiques, S.A., Couillet, Belgium.
- Division de Couillet. (*Ingots, blooms, bars, forgings and castings.*) (ANTWERP.)
- Division de Montignies et Chatelineau. (*Rolling mill.*) (ANTWERP.)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre, Belgium. (*Castings.*) (ANTWERP.)

Lesquin-lez-Lille (Nord), France. (*Castings.*) (VALENCIENNES.)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small forgings and castings.*) (YOKOHAMA.)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Bars.*) STOCKHOLM.)

Hatakeyama Iron Works Co., Ltd., Komatsugawa Works, Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Helsingors Skibsvaerft-og Maskinbyggeri A/S, Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*) (COPENHAGEN.)

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Castings.*) (NANTES.)

Henricot, Usines Emile, Court St. Etienne, Belgium. (*Castings.*) (ANTWERP.)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*) (VALENCIENNES.)

Hitachi, Ltd.,
- Hitachi Works, Hitachi, Japan. (*Castings.*) (YOKOHAMA.)
- Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*) (SHIMONOSEKI.)
- Mito Works, Katsutashi, Ibaragi-ken, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Hitachi Metal Industries, Ltd.,
- Yasugi Works, Yasugi, Japan. (*Ingots and bars.*) (KOBE.)
- Tobata Works, Tobata, Japan. (*Castings.*) (SHIMONOSEKI.)

Hitachi Shipbuilding & Engineering Co., Ltd.,
- Chikko Shipyard, Osaka, Japan. (*Castings and forgings.*) (KOBE.)
- Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*) (KOBE.)

Hoesch-Westfalenhütte A.G., Dortmund, Germany. (*Ingots, billets, plates, bars and sections.*) (DORTMUND.)

Hokuriku Kogyo Co., Ltd., Sanjo Plant, Sanjo, Niigata Prefecture, Japan. (*Small forgings.*) (YOKOHAMA.)

Howa Machinery, Ltd., Aichi Prefecture, Japan. (*Castings.*) (KOBE.)

Huta 1-Go Maja, Gliwice, Poland. (*Forgings.*) (KATOWICE.)

Huta Baildon, Katowice, Poland. (*Ingots, forgings and bars.*) (KATOWICE.)

Huta Batory, Chorzow-Batory, Poland. (*Forgings, plates and tubes.*) (KATOWICE.)

Huta Bieruta, Czestochowa, Poland. (*Seamless tubes.*) (KATOWICE.)

Huta Bobrek, Bytom, Poland. (*Ingots, slabs and blooms.*) (KATOWICE.)

Huta Dzierzynskiego, Dabrowa Gornicza, Poland. (*Billets, sections and bars.*) (KATOWICE.)

Huta Florian, Swietochlowice, Poland. (*Angles and bars.*) (KATOWICE.)

Huta Jednosc, Siemianowice Slaskie, Poland. (*Ingots and seamless tubes.*) (KATOWICE.)

Huta Kosciuszko, Chorzow, Poland. (*Billets, blooms, sections and rivet bars.*) (KATOWICE.)

Huta Labedy, Labedy, Poland. (*Flats and sections.*) (KATOWICE.)

Huta Lenina, Krakow, Poland. (*Ingots, slabs, plates up to 12 mm.*) (KATOWICE.)

Huta Malapanew, Ozimek k/Opola, Poland. (*Castings.*) (KATOWICE.)

Huta Nowotki, Ostrowiec Swietokrzyski, Poland. (*Sections.*) (KATOWICE.)

Huta Pokoj, Nowy Bytom, Poland. (*Plates and sections.*) (KATOWICE.)

Huta Sosnowiec, Sosnowiec, Poland. (*Castings and seamless tubes.*) (KATOWICE.)

Huta Stalowa Wola, Stalowa Wola, Poland. (*Castings, forgings, plates and sections.*) (KATOWICE.)

Huta Z.M.G.S., Elblag, Poland. (*Castings.*) (GDANSK.)

Huta Zawiercie, Zawiercie, Poland. (*Flats and bars.*) (KATOWICE.)

Hutten-und Bergwerke Rheinhausen A.G., Hüttenwerk Rheinhausen, Rheinhausen, Germany. (*Bars and sections only.*) (DUSSELDORF.)

Hüttenwerk Oberhausen A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Hüttenwerk Salzgitter A.G., Salzgitter - Drütte, Germany. (*Ingots and plates.*) (HANOVER.)

Hüttenwerke Siegerland A.G., Niederschelden, Germany. (*Ingots and slabs.*) (COLOGNE.)

Iino Shipbuilding & Engineering Co., Ltd., Maizuru Dockyard, Maizuru, Japan. (*Forgings and castings.*) (KOBE.)

Ilseder Hutte A.G., Peine, Germany. (*Ingots, billets, sections and bars.*) (HANOVER.)

d'Imphy, Société Métallurgique, Aciéries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*) (LYONS.)

Indian Iron & Steel Co., Ltd., Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*) (CALCUTTA.)

Indian Tube Company, (1953) Ltd., Jamshedpur, India. (*Seamless tubes.*) (CALCUTTA.)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W., Australia. (*Castings.*) (SYDNEY.)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*) (BARCELONA.)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*) (CLEVELAND, O.)

Isaacson Iron Works, P.O. Box 3028, Seattle 14, Wash., U.S.A. (*Ingots.*) (SEATTLE.)

Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi Works, Aioi, Japan. (*Castings and forgings.*) (KOBE.)

Ishikawajima Heavy Industries Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Ishikawajima Shibaura Turbine Co., Ltd., Tokyo, Tsurumi Plant, Yokohama, Japan. (*Small castings.*) (YOKOHAMA.)

Izuo Chukosho Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

"ITALSIDER" Alti Forni e Acciaierie Ri unite Ilva e Cornigliano S.p.A., Head Office: Genoa, Italy.

- Stabilimento di Bagnoli. (*Ingots, sections and bars.*) (NAPLES.)
- Stabilimento di Genoa-Cornigliano. (*Ingots and plates.*) (GENOA.)
- Stabilimento di Genoa-Voltri. (*Rivets.*) (GENOA.)
- Stabilimento di Lovere. (*Sections, bars, castings and forgings.*) (MILAN.)
- Stabilimento di Marghera. (*Castings, also rolling mills for small sections and bars.*) (VENICE.)
- Stabilimento di Novi Ligure. (*Sections, bars and plates.*) (GENOA.)
- Stabilimento di Portovecchio di Piombino. (*Ingots, blooms, sections and bars.*) (LEGHORN.)
- Stabilimento di Servola. (*Ingots and plates.*) (TRIESTE.)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*) (ANTWERP.)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Forgings.*) (YOKOHAMA.)

Japan Steel Works Ltd.,

- Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*) (SHIMONOSEKI.)
- Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*) (YOKOHAMA.)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*) (ANTWERP.)

Jeumont, Forges et Ateliers de Constructions Electriques de, Jeumont (Nord), France. (*Castings.*) (VALENCIENNES.)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A. (PITTSBURGH.)

K.G.M.-Altalanos Gepipari Igazgatosag, Budapest, Hungary.

- *Works*: Kobanyai Vas-es Acelontode, Budapest. (*Castings.*) (VIENNA.)

K.G.M. Jarmuipari Igazgatosag, Budapest, Hungary.

- *Works*: Wilhelm Pieck Vagon es Gepgyar, Gyor. (*Castings.*) (VIENNA.)

K.G.M. Vaskohászati Igazgatóság, Budapest, Hungary.
Works: Lenin Kohászati Müvek, Miskole-Diósgyör. (*Ingots, slabs, sections, bars, castings and forgings.*) (VIENNA.)
Works: Lörinci Hengermü, Budapest. (*Rolling mill for plates.*) (VIENNA.)
Works: Ozdi Kohászati üzemek, Ozd. (*Ingots, slabs, plates, sections and bars.*) (VIENNA.)

K.K. Teikoku Kokan Seizosho, Osaka, Japan. (*Seamless tubes.*) (KOBE.)

K.M. Steel Products Pty., Ltd., Brooklyn, Melbourne, Australia. (*Ingots*) (MELBOURNE.)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*) (LOS ANGELES.)

Kakegawa Endo Iron Works Co., Ltd., Kakegawa, Japan. (*Forgings.*) (YOKOHAMA.)

Kansai Tekko Co., Ltd., Amagasaki, Japan. (*Small forgings.*) (KOBE.)

Kanthal, A/B, Hallstahammar, Sweden. (*Ingots, billets, bars and castings.*) (STOCKHOLM.)

Kanto Special Steel Works, Ltd., Fujisawa, Kanagawa Pref., Japan. (*Forgings.*) (YOKOHAMA.)

Kanto Steel Co., Ltd., Shibukawa Works, Shibukawa, Japan. (*Ingots, small forgings and bars.*) (YOKOHAMA.)

Kawaguchi Kinzoku Kogyo Kabushiki Kaisha, Kawaguchi, Japan. (*Castings*). (YOKOHAMA.)

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Forgings and castings.*) (KOBE.)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*) (KOBE.)

Kawasaki Steel Corporation.
Chiba Works, Chiba. (*Slabs for plates.*) (YOKOHAMA.)
Fukiai Works, Kobe. (*Plates.*) (KOBE.)
Hyogo Works, Kobe. (*Castings and forgings.*) (KOBE.)
Nishinomiya Works, Nishinomiya. (*Rolling mills for plates up to 14 mm. in thickness.*) (KOBE.)

Kilby Steel Co., Furnace Division, Anniston, Alabama, U.S.A. (*Ingots.*) (MOBILE.)

Klafreströms Bruk, A/B., Klavreström, Sweden. (*Small castings.*) (GOTHENBURG.)

Klinger, Rich., Aktiengesellschaft, Gumpoldskirchen, near Vienna, Austria. (*Small castings.*) (VIENNA.)

Klockner-Werke A.G., Hütte Bremen, Germany. (*Plates.*) (BREMEN.)

Klöckner-Huttenwerk Haspe, A.G. Hütte-Haspe, Hagen-Haspe, Germany. (*Ingots, plates, bars and sections.*) (DORTMUND.)

Klöckner - Mannstaedtwerke G.m.b.H., Troisdorf, Germany. (*Rolling mills for sections.*) (COLOGNE.)

Klöckner-Werke A.G., Georgsmarienwerke, Osnabrück, Germany. (*Ingots, bars, forgings and castings.*) (HANOVER.)

Kobe Steel Works, Ltd., Kobe, Japan. (*Castings, forgings and bars.*) (KOBE.)

Kobe Steel Works, Ltd., Takasago Plant, Arai, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*) (MALMO.)

Kohlswa Jernverks Aktiebolag. (*Ingots, forgings and castings.*) (STOCKHOLM.)

Kokko Steel Manufacturing Co., Ltd., Osaka, Japan. (*Angles, bars and castings.*) (KOBE.)

Komatsu Manufacturing Co., Ltd.,
Komatsu, Japan. (*Castings.*) (KOBE.)
Osaka Plant, Hirakata, Osaka Prefecture, Japan. (*Castings.*) (KOBE.)

Koninklijke Demka Staalfabrieken N.V., Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*) (AMSTERDAM.)

Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*) AMSTERDAM.)

Kotobuki Kogyo Co., Ltd., Hiro Works, Kure, Japan. (*Castings.*) (SHIMONOSEKI.)

Krauss-Maffei A.G., München-Allach, Germany. (*Castings.*) (AUGSBURG.)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Kureha Seitetsu Co., Ltd., Toyama, Japan. (*Ingots.*) (YOKOHAMA.)

Kurimoto Iron Works Ltd., Kagaya Works, Osaka, Japan. (*Castings*). (KOBE.)

La Maquinista Terrestre y Maritima, S.A., Barcelona, Spain. (*Castings and forgings.*) (BARCELONA.)

Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*) (VALENCIENNES.)

Larssons, A/B P.S., Gjuteri & Aduceringsverk, Eskilduna, Sweden. (*Castings.*) (STOCKHOLM.)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Leonard-Giot, Société Anonyme Usines & Aciéries, Marchienne-au-Pont, Belgium. (*Castings.*) (ANTWERP.)

Les Aciéries de la Meuse, S.A., Cheratte-lez-Liege, Belgium. (*Castings.*) (ANTWERP.)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Ingots and bars.*) (GOTHENBURG.)

Llodio, Ltda., Aceros de, Llodio, near Bilbao, Spain. (*Small castings, ingots, forgings and rolled bars.*) (BILBAO.)

Lokomo Oy, Tampere, Finland. (*Ingots, forgings and castings.*) (ÅBO.)

Lorraine-Escaut S.A.,
Departement Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*) (VALENCIENNES.)
Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle), France. (*Sections and plates.*) (SAAR.)
Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle), France. (*Ingots, blooms, bars and sections.*) (SAAR.)

Usine de Sedan, Sedan (Ardennes), France. (*Plates.*) (VALENCIENNES.)

Usine de Thionville, Thionville (Moselle), France. (*Forgings.*) (SAAR.)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*) (LOS ANGELES.)

Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*) (PHILADELPHIA.)

Luzuriaga, Victorio, S.L., Pasajes, Guipuzcoa, Spain. (*Castings.*) (BILBAO.)

Lynn Macleod Metallurgy Ltd., Thetford Mines, P.Q., Canada. (*Castings.*) (MONTREAL.)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*) (KOBE.)

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*) (ISTANBUL.)

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*) (DURBAN.)

Manitoba Rolling Mill Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*) (MONTREAL.)

Mannesmann Hüttenwerke A.G., Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*) (DUSSELDORF.)

Manufacturas de Acero S.A., Badalona, Barcelona, Spain. (*Small castings.*) (BARCELONA.)

Maritime Steel and Foundries, Ltd., New Glasgow, Nova Scotia. (*Small castings.*) (HALIFAX, N.S.)

Marpent, Aciéries & Ateliers de Construction de, Marpent (Nord), France. (*Castings.*) (VALENCIENNES.)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais, France. (*Castings.*) (VALENCIENNES.)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Gier (Loire), France. (*Ingots, forgings, plates and bars.*) (MARSEILLES.)

Mason & Cox, Ltd., Adelaide, S. Australia. (*Castings.*) (ADELAIDE.)

Material y Construcciones S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Matsuya Kogyo Co., Ltd., Fukuoka, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord), France. (*Ingots and plates.*) (VALENCIENNES.)

Maurice Dembiermont & Cie., Hautmont, (Nord), France. (*Forgings.*) (VALENCIENNES).

Meridionale, Acciaierie e Tubificio, S.p.A., Bari, Italy. (*Castings and weldless rolled or drawn tubes.*) (NAPLES.)

Meridionales, Fonderies, Marseilles, France. (*Castings.*) (MARSEILLES.)

Metal & Steel Factory, Ishapore, West Bengal, India. (*Ingots, blooms, billets and forgings.*) (CALCUTTA.)

Metallurgica Marcora, Busto Arsizio (Varese), Italy. (*Weldless rolled and drawn tubes.*) (MILAN.)

Metalurgica Duarte Ferreira S.A.R.L., Tramagal, Portugal. (*Castings.*) (LISBON.)

Meuse, Société Métallurgique de la, Forges et Aciéries de Stenay, Stenay, Meuse. (*Small castings.*) (VALENCIENNES.)

MIAG (Muhlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*) (HANOVER.)

Midvale-Heppenstall Company, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Mineracao Geral do Brazil, Lda., Sao Paulo, Brazil. (*Ingots and weldless tubes.*) (RIO DE JANEIRO.)

Mitsubishi Heavy Industries Reorganized Ltd.,

Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Mihara Engineering Works, Mihara, Japan. (*Castings and forgings.*) (KOBE.)

Mitsubishi Kozai Kabushiki Kaisha, Tokyo, Japan.

Main Works. (*Rolling mills for billets and bars.*) (YOKOHAMA.)

Fukagawa Works. (*Billets and bars.*) (YOKOHAMA.)

Hirota Works. (*Ingots.*) (YOKOHAMA.)

Mitsubishi Nippon Heavy Industries Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*) (YOKOHAMA.)

Mitsubishi Shipbuilding and Engineering Co., Ltd.,

Hiroshima Works, Hiroshima, Japan. (*Ingots, castings and small forgings.*) (SHIMONOSEKI.)

Hiroshima Precision Machine Works, Hiroshima, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*) (SHIMONOSEKI.)

Shimonoseki Works, Shimonoseki, Japan. (*Small forgings.*) (SHIMONOSEKI.)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Japan. (*Ingots, blooms, plates, forgings and castings.*) (SHIMONOSEKI.)

Mitsuboshi Iron Works Co., Ltd., Osaka, Japan. (*Small forgings.*) (KOBE.)

Mitsui Miike Machinery Co., Ltd., Miike Works, Omutashi, Japan. (*Castings.*) (SHIMONOSEKI.)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Ingots, forgings and castings.*) (KOBE.)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small castings.*) (KOBE.)

Montluçon, Commentry, Société des Forges et Ateliers de, Usines St. Jacques, Montluçon (Allier), France. (*Castings, ingots, forgings, sheets and sections.*) (MARSEILLES.)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*) (GOTHENBURG.)

Motomeccanica, Società per Azioni, Milan, Italy. (*Small castings.*) (MILAN.)

Mukand Iron & Steel Works, Ltd., Kurla, Bombay,37, India. (*Castings.*) (BOMBAY.)

Nakayama Steel Works, Osaka, Japan. (*Ingots, forgings, and plates up to 25 mm. in thickness.*) (KOBE.)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*) (CALCUTTA.)

National Malleable and Steel Castings Co., Sharon, Pa., U.S.A. (*Castings.*) (PITTSBURGH.)

Nazionale "Cogne", S.p.A. *Head Office:* Turin. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*) (GENOA.)

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*) (NEWPORT NEWS.)

Nihon Cast Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*) (YOKOHAMA.)

Nippon Chuzo Kabushiki Kaisha, Kawasaki, Japan. (*Ingots and castings.*) (YOKOHAMA.)

Nippon Kokan Kabushiki Kaisha.

Asano Dockyard, Yokohama, Japan. (*Forgings.*) (YOKOHAMA.)

Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*) (YOKOHAMA.)

Mizue Ironworks, Kawasaki, Japan. (*Plates up to ½-inch in thickness.*)

Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Plates.*) (YOKOHAMA.)

Nippon Sharyo Seizo Kaisha, Ltd., Nagoya, Japan. (*Castings.*) (KOBE.)

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*) (YOKOHAMA.)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*) (KOBE.)

Nippon Tanko Co., Ltd., Amagasaki, Japan. (*Small forgings.*) (KOBE.)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*) (YOKOHAMA.)

Nisshin Seiko Co., Ltd., No. 1 Shikama Plant, Himeji, Japan. (*Rolled bars.*) (KOBE.)

Nisshin Steel Works, Ltd., Kure Works, Kure, Japan. (*Ingots, blooms, billets and strip.*) (SHIMONOSEKI.)

Nisso Steel Manufacturing Co., Ltd.,

Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots.*) (YOKOHAMA.)

Oshima Plant, Tokyo, Japan. (*Castings, plates, and ingots for forging and plate.*) (YOKOHAMA.)

Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*) (YOKOHAMA.)

Nittoku Metal Industry Co., Ltd., Tokyo, Japan. (*Small forgings.*) (YOKOHAMA.)

Nordische Stahlwerke, Bach & Co., Neumünster, Germany. (*Castings.*) (KIEL.)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*) (STOCKHOLM.)

Norsk Jernverk, A/S., Mo-i-Rana, Norway. (*Electric steel ingots, billets, sections and bars.*) (OSLO.)

Nová hut Klementa Gottwalda, národni podnik (New Metallurgical Works of Klement Gottwald, National Corporation), Ostrava-Kunčice, Czechoslovakia. (*Ingots and forgings.*) (VIENNA.)

O.R.I.O.N. S.p.A., Petro-Chimica Dal Pozzo, Porto Industriale, Trieste, Italy. (*Forgings and castings.*) (TRIESTE.)

Oesterreichisch-Alpine Montangesellschaft, Vienna.

Works: Donawitz, Styria. (*Plates and sections.*) (VIENNA.)

Works: Kindberg, Styria. (*Rolling mills for small sections and bars.*) (VIENNA.)

Works: Traisen, Low Austria. (*Castings.*) (VIENNA.)

Works: Wördern, Low Austria. (*Ingots.*) (VIENNA.)

Works: Zeltweg, Styria. (*Forged bars.*) (VIENNA.)

Officine Meccaniche e Fonderie Napoletane, Naples, Italy. (*Castings.*) (NAPLES.)

Ohtani Heavy Industrial Co., Ltd., Amagasaki Plant, Amagasaki, Japan. (*Plates up to 12,5 mm. in thickness.*) (KOBE.)

Okamoto Iron Works Co., Kobe, Japan. (*Small forgings.*) (KOBE.)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*) (SHIMONOSEKI.)

Olarra S.A. Larrondo, Lujua, Vizcaya, Spain. (*Ingots and rolled bars.*) (BILBAO.)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*) (KOBE.)

Osaka Steel Tube Co., Ltd., Sasebo Works, Sasebo, Japan. (*Seamless tubes.*) (SHIMONOSEKI.)

Oxelosunds Jarnverk, Oxelosund, Sweden. (*Ingots, rolled slabs and plates.*) (STOCKHOLM.)

Pacific States Steel Corporation, Niles, Cal., U.S.A. (*Ingots, sections and bars.*) (SAN FRANCISCO.)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*) (SAN FRANCISCO.)

Pacifico, Compañia de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*) (TALCAHUANO.)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais, France. (*Castings.*) (VALENCIENNES.)

Paris-Seine, Fonderies et Aciéries de, Usine de la Folie, Avenue de Bobigny, Noisy le Sec (Seine), France. (*Castings.*) (PARIS.)

Pencoyd Steel & Forge Corporation, 3720-40, Main Street, Philadelphia 27, Pa., U.S.A. (*Ingots and forgings.*) (PHILADELPHIA.)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*) (PHILADELPHIA.)

Pennsylvania Electric Steel Casting Co., Hamburg, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Pennsylvania Forge, Division of Chemetron Corporation, Tacony, Philadelphia, 35, Pa., U.S.A. (*Forgings.*) (PHILADELPHIA.)

Phoenix-Rheinrohr A.G., Mulheim-Ruhr, Germany. (*Plates.*) (DUSSELDORF.)

Phoenix Steel Corporation.

Works: Claymont, Delaware, U.S.A. (*Plates.*) (PHILADELPHIA.)

Works: Plate Division, Harrisburg, Pa., U.S.A. (*Rolling mills.*) (PHILADELPHIA.)

Works: Structural Division, Phoenixville, Pa., U.S.A. (*Sections, bars and rotary forged seamless tubes.*) (PHILADELPHIA.)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A.

Works: Monessen, Pa. (*Ingots, billets and slabs.*) (PITTSBURGH.)

Works: Allenport, Pa. (*Rolling mills.*) (PITTSBURGH.)

Pompey, Société des Aciéries de,

Usine de Dieulouard, Meurthe & Moselle, France. (*Ingots, blooms, billets and bars.*) (SAARBRÜCKEN-SAAR.)

Usine de Pompey, Meurthe & Moselle, France. (*Ingots, plates, angles and round bars.*) (SAARBRÜCKEN-SAAR.)

Usine du Manoir à Pitres, Eure, France. (*Castings.*) (ROUEN.)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*) (MARSEILLES.)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections, bars, ingots and blooms*). (ANTWERP.)

Quaker Alloy Casting Co., Myerstown, Pa., U.S.A. (*Small castings.*) (PHILADELPHIA.)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*) (STOCKHOLM.)

Raufoss Ammunisjonsfabrikker, Raufoss, Norway. (*Castings.*) (OSLO.)

Republic Steel Corporation, Cleveland, O., U.S.A.

Alabama City, Ala., U.S.A. (MOBILE, ALA.)

Buffalo Plant, Buffalo, N.Y., U.S.A. (CLEVELAND,O.)

Central Alloy District, Massillon Plant, Massillon, O. U.S.A. (CLEVELAND, O.)

Chicago Plant, Chicago, Ill., U.S.A.

Works: 118th Street, Chicago. (*Rolling mills.*) East Chicago, Ind. (*Angles and bars.*) (CLEVELAND, O.)

Cleveland District, Cleveland, O., U.S.A. (CLEVELAND, O.)

Corrigan McKinney Plant. (*Ingots, blooms and billets.*)

Upson Nut Plant. (*Round and square bars.*)

Youngstown District, Youngstown, O., U.S.A. (PITTSBURGH.)

Riken Tanzo Co., Ltd., Maebashi Plant, Maebashi, Japan. (*Small forgings.*) (YOKOHAMA.)

Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen, Saar. (*Castings, ingots, billets, bars and forgings.*) (SAARBRÜCKEN-SAAR.)

Rosenlew, W., & Co., A/B Björneborgs Mekaniska Verkstad, Björneborg, Finland. (*Small castings.*) (ÅBO.)

Rotterdamsche Droogdok Maatschappij, Rotterdam, Holland. (*Ingots, forgings and small castings.*) (ROTTERDAM.)

Ruhrstahl A.G., Henrichshütte, Hattingen-Ruhr, Germany. (*Ingots, plates, forgings and castings.*) (DORTMUND.)

S.A.F.A.U. Ferriere Acciaierie di Udine, Udine, Italy. (*Forgings and castings.*) (TRIESTE.)

Sambre, Aciéries & Minières de la,

Works: Monceau-sur-Sambre, Belgium. (*Sections, bars, billets and blooms.*) (ANTWERP.)

Works: Moncheret, near Acoz. (*Rolling mills for bars.*) (ANTWERP.)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de,

Usines de Feignies, Feignies (Nord), France. (*Castings.*) (VALENCIENNES.)

Usines de Saint Brieuc, Cotes-du-Nord, France. (*Small castings.*) (NANTES.)

Sande Giesserei, Sande-Oldenburg, Germany. (*Castings.*) (EMDEN.)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings and tubes.*) (STOCKHOLM.)

"Santa Barbara," Sociedad Industrial Asturiana,Fábricas de Moreda y Gijon, Gijon, Spain. (*Rivet bars.*) (GIJON.)

Sanyo Special Steel Co., Ltd., Himeji, Japan. (*Small forgings.*) (KOBE.)

Sasebo Ship Industry Co., Ltd., Sasebo, Japan. (*Castings and forgings.*) (SHIMONOSEKI.)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juery (Tarn), France. (*Castings.*) (MARSEILLES.)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*) (VEREENIGING.)

Schmidt & Clemens, Edelstahlwerk, Berghausen b/Engelskirchen, Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*) (COLOGNE.)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.

Works: Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*) (VIENNA.)

Works: Ternitz, Low Austria. (*Castings, forgings and bars.*) (VIENNA.)

Schutte, Meyer & Co., G.m.b.H., Letmathe, Westphalia, Germany. (*Small castings.*) (DORTMUND.)

Schütze, A.G., Ludwigshafen-Oggersheim, Germany. (*Electric steel castings.*) (MANNHEIM.)

Sesto San Giovanni, Acciaierie Elettriche di, S.p.A., Sesto San Giovanni, Milan, Italy. (*Castings.*) (MILAN.)

Shimizu Tanzo Kabushiki Kaisha, Tokyo, Japan. (*Forgings.*) (YOKOHAMA.)

Shin Nippon Tanko K.K., Kawasaki, Japan. (*Small forgings.*) (YOKOHAMA.)

S.I.S.M.A. — Società Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara), Italy. (*Rolled bars and rivets.*) (MILAN.)

SKF. Hofors Bruk, Hofors, Sweden. (*Billets, bars and forgings, and thick walled tubes.*) (STOCKHOLM.)

Smedjebackens Valsverks Aktiebolag, Smedjebacken, Sweden. (*Sections, castings and ingots for re-rolling.*) (STOCKHOLM.)

Società Italiana Acciaierie Cornigliano. *Head Office:* Genoa. *Works:* Genoa-Cornigliano. (*Ingots, forgings, plates and castings.*) (GENOA.)

Societa Metallurgica Vittorio Cobianchi S.p.A.
Head Office: Milan, Italy.
Works: Omegna (NOVARA.) (*Castings*) (MILAN.)

Société Anonyme d'Exploitation des Aciéries de Bordeaux, Pessac, Gironde, France. (*Castings.*) (BORDEAUX.)

Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*) (SAARBRÜCKEN-SAAR.)

Société Belge Griffin S.A., Merxem, Antwerp, Belgium. (*Castings.*) (ANTWERP.)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*) (SAAR.)

Société Métallurgique d'Imphy.
Aciéries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*) (MARSEILLES.)
Usine de Pamiers (Ariège), France. (*Castings and forgings.*) (MARSEILLES.)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*) (ROUEN.)

Sorel Industries, Ltd., Sorel, P.Q., Canada. (*Ingots and forgings.*) (MONTREAL.)

South African Iron & Steel Industrial Corporation, Ltd., "Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to 9,5 mm. thick.*) (VEREENIGING.)
"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*) (VEREENIGING.)

S.p.A., Fonderie Elettriche O. Pracchi, Milan, Italy. (*Small castings.*) (MILAN.)

Stahl-u. Röhrenwerke Reisholz A.G., Abt. Oberbilker Stahlwerk, Düsseldorf-Oberbilk, Germany. (*Ingots and forgings.*) (DUSSELDORF.)

Stahlwerk Mannheim A.G., Mannheim-Rheinau, Germany. (*Ingots, forgings and castings.*) (MANNHEIM.)

Stahlwerk Mark, Wengern A.G., Wengern-Ruhr, Germany. (*Ingots and castings.*) (DUSSELDORF.)

Stahlwerk Südwestfalen, A.G.,
Werk Geisweid, Geisweid Kreis Siegen, Germany. (*Ingots, forgings, bars and thin plates.*) (COLOGNE.)
Werk Harkort Eicken, Hagen, Germany. (*Ingots, bars and forgings.*) (DORTMUND.)

Stahlwerke Bochum A.G., Bochum, Germany. (*Castings, forgings, rolled materials and plates.*) (DUSSELDORF.)

Stahlwerke Röchling-Buderus A.G., Wetzlar, Germany. (*Ingots, blooms, billets, bars, forgings and plates.*) (COLOGNE.)

Stål och Maskinaktiebolaget, Upsala, Sweden. (*Ingots.*) (STOCKHOLM.)

Standard Steel Works Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*) (PHILADELPHIA.)

Stavanger Electro-Staalverk A.S., Jørpeland, near Stavanger, Norway. (*Castings.*) (BERGEN.)

Steel Company of Australia, Pty. Ltd., Coburg, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Steel Company of Canada, Hamilton, Ontario, Canada.
Works: Hamilton. (TORONTO.)
Works: Montreal. (*Bars, angles, plates and billets.*) (MONTREAL.)

Steirische Gusstahlwerke, A.G., Vienna. *Works:* Judenburg, Styria, Austria. (*Forgings and bars.*) (VIENNA.)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.
Works: Domnarfvet. (*Castings, ingots, sections and plates.*) (STOCKHOLM.)
Works: Söderfors. (*Forgings, bars and sections.*) (STOCKHOLM.)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema, Italy. (*Ingots, bars, small sections and rivets.*) (MILAN.)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*) (AUGSBURG.)

Strömmens Verksted, A/S, near Oslo, Norway. (*Castings.*) (OSLO.)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*) (BARCELONA.)

Sud Ouest, Société des Forges et Aciéries du, Bordeaux (Gironde), France. (*Castings and forgings.*) (BORDEAUX.)

Sulzer Frères, Société Anonyme, Winterthur, Switzerland. (*Castings.*) (WINTERTHUR.)

Sumitomo Electric Industries, Ltd., Itami Works, Itami, Hyogo Prefecture, Japan. (*Ingots and small bars.*) (KOBE.)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*) (KOBE.)

Sumitomo Metal Industries, Ltd.,
Kokura Steel Works, Kokura, Japan. (*Ingots, billets, bars and sections.*) (SHIMONOSEKI.)
Osaka Steel Works, Osaka. (*Castings and forgings.*) (KOBE.)
Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*) (KOBE.)
Wakayama Steel Works, Wakayama, Japan. (*Small ingots, seamless tubes and electric resistance welded tubes.*) (KOBE.)

Sunnan Iron Works Co., Ltd., Yaizu, Japan. (*Forgings.*) (YOKOHAMA.)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Plates, forgings and castings.*) (STOCKHOLM.)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*) (STOCKHOLM.)

Svenska Kullagerfabriken, Aktiebolaget, Katrineholm, Sweden. (*Castings.*) (STOCKHOLM.)

Taira Steel Works, Osaka Shipbuilding Co., Ltd., Taira, Fukushima Prefecture, Japan. (*Castings.*) (YOKOHAMA.)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*) (KOBE.)

Takasaki Metal Industry Co., Ltd., Takasaki Plant, Takasaki, Japan. (*Small castings.*) (YOKOHAMA.)

Tamaris, Société des Ateliers et Fonderies de, Tamaris (Gard), France. (*Castings.*) (MARSEILLES.)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Blooms, billets, bars, plates and sections.*) (CALCUTTA.)

Tata Locomotive & Engineering Co., Ltd., Jamshedpur 4, India. (*Castings.*) (CALCUTTA.)

Teil, Fonderies & Aciéries du, Usine du Frayol, Le Teil (Ardeche), France. (*Small castings.*) (MARSEILLES.)

Tennessee Coal & Iron Division, United States Steel Corporation, Birmingham, Ala., U.S.A. *Works:* Ensley, Ala. *Rolling mills, also forgings:* Bessemer and Fairfield, Ala. (MOBILE.)

"Terni" Società per l'Industria e l'Elettricita. *Works :* Terni, Italy. (*Ingots, forgings, castings and plates.*) (NAPLES.)

Thompson's (Castlemaine) Ltd., Williamstown, Victoria, Australia. (*Castings.*) (MELBOURNE.)

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*) (SPLIT.)

Toho Seiko Kabushiki Kaisha, Nagoya, Japan. (*Castings.*) (KOBE.)

Tohoku Special Steel Works Ltd., Sendai, Japan. (*Ingots, small forgings, billets and bars.*) (YOKOHAMA.)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki Works, Kawasaki, Japan. (*Ingots, forgings and bars.*) (YOKOHAMA.)

Tokyo Kikai Kabushiki Kaisha, Oshima Cast Steel Works, Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Tokyo Tankosho Co., Ltd., Kawasaki Factory, Kawasaki, Japan. (*Small forgings.*) (YOKOHAMA.)

Toshiba Steel Co., Ltd., Tokyo, Japan. (*Castings, small forgings, sections and ingots for forging and plates.*) (YOKOHAMA.)

Tosi, Franco, Società per Azioni, Legnano, Italy. (*Forgings and castings.*) (MILAN.)

Toto Steel Manufacturing Co., Ltd.

Tokyo Plant, Tokyo, Japan. (*Sections.*) (YOKOHAMA.)

Chigasaki Foundry, Chigasaki, Japan. (*Ingots for forging, castings.*) (YOKOHAMA.)

Trefilerias del Nervion S.A., Erandio, Bilbao, Spain. (*Ingots and small bars.*) (BILBAO.)

Trinecké železárny velké Rijnové socialistické revoluce, národni podnik (Třinec Iron Works Great-Socialistic October Revolution National Corporation), Třinec, Czechoslovakia. (*Ingots, sections, bars and castings.*) (VIENNA.)

Trubia, Fábrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*) (GIJON.)

Tsukamoto Sogyo Co., Ltd., Osaka Works, Osaka, Japan. (*Castings.*) (KOBE.)

Turkiye Demir ve Celik Fabrikalari, Karabuk, Turkey (*Ingots, plates, rolled sections and bars.*) (ISTANBUL.)

Tvornica Dizalica "Vulkan", Rijeka II, Yugoslavia. (*Castings.*) (RIJEKA.)

Ube Industries, Ltd., Ube Iron Works, Ube, Japan. (*Ingots, forgings and castings.*) (SHIMONOSEKI.)

Uddeholms Aktiebolag, Uddeholm, Sweden.

Works : Storfors. (*Seamless tubes.*) (GOTHENBURG.)

Works : Nykroppa. (*Ingots, forgings and bars.*) (GOTHENBURG.)

Works : Hagfors. (*Castings.*) (GOTHENBURG.)

Ugine, Aciéries Electriques d', Ugine (Savoie), France. (*Ingots, billets, bars, sections, castings and forgings.*) (MARSEILLES)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*) (LISBON.)

Union de Consommateurs de Produits Métallurgiques et Industriels, U.C.P.M.I., Forges et Aciéries d'Hagondange, Hagondange, Moselle, France. (*Blooms, billets, bars and sections.*) (SAAR.)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi, Belgium. (*Castings.*) (ANTWERP.)

Union Sidérurgique Lorraine, SIDELOR.

Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and plates.*) (SAAR.)

Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (SAAR.)

Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*) (SAAR.)

Union Sidérurgique du Nord de la France.

USINOR GROUPE A.

Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*) (VALENCIENNES.)

USINOR GROUPE B.

Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*) (VALENCIENNES.)

Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*) (VALENCIENNES.)

Union Steel Corporation of South Africa, Ltd. (Usco).
Works: Vereeniging, Transvaal, South Africa. (*Ingots, billets, small sections, castings and rivet bars.*) (VEREENIGING.)

United States Steel Corporation, Pittsburgh, Pa., U.S.A.
Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*) (PITTSBURGH.)
Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*) (PITTSBURGH.)
Fairless Works, Morrisville, Pa. (*Thin plates, bars and sections.*) (PHILADELPHIA.)
Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*) (CLEVELAND, O.)
Homestead District Works, Pa., including McKees Rock Works. (*Ingots, billets, blooms, slabs, plates, sections and forgings.*) (PITTSBURGH.)
Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*) (PITTSBURGH.)
McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*) (PITTSBURGH.)
Ohio Works, Youngstown. (*Ingots, billets and blooms.*) (PITTSBURGH.)
South Works, South Chicago, Ill. (*Plates, sections and bars.*) (CLEVELAND, O.)

Uraga Shipbuilding Yard, Uraga Dock Co., Ltd., Yokosuka, Japan. (*Castings and small forgings.*) (YOKOHAMA.)

Uraga Tamashima Diesel Kogyo K.K., Tamashima Factory, Tamashima, Japan. (*Small forgings.*) (KOBE.)

Vallourec, Société, Usine d'Aulnoye, Aulnoye (Nord), France. (*Weldless rolled and drawn tubes.*) (VALENCIENNES.)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*) (VEREENIGING.)

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*) (COPENHAGEN.)

Vereinigte Oesterreichische Eisen-und-Stahlwerke, A.G.
Works: Liezen, Styria. (*Ingots for forgings, castings.*) (VIENNA.)
Works: Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*) (VIENNA.)

Vicinay S.A., Luchana-Bilbao, Bilbao, Spain. (*Ingots, castings and small forgings.*) (BILBAO.)

Vickers Ruwolt Pty., Ltd., Richmond, Melbourne, Australia. (*Castings.*) (MELBOURNE.)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*) (VANCOUVER.)

Villa, Giovanni, S.p.A., Officine Meccaniche-Fucinati-Stampati, Milan, Italy. (*Forgings.*) (MILAN.)

Vitkovické Železárny Klementa Gottwalda, národni podnik (The Vitkovice Steel Works Klement Gottwald, National Corporation), Ostrava 10, Czechoslovakia. (*Castings, forgings, plates, sections, bars and seamless tubes.*) (VIENNA.)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*) (VALENCIA.)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*) (BILBAO.)

Vuoksenniska Oy Aktiebolag, Imatra Ironworks, Imatra, Finland. (*Ingots, slabs, blooms and billets, bars and sections.*) (HELSINGFORS.)

Waagner-Biro Aktiengesellschaft, Vienna, Austria.
Works: Werk C, Vienna. (*Castings.*) (VIENNA.)

Walkers Ltd., Maryborough, Queensland, Australia. (*Forgings and castings.*) (BRISBANE.)

Wärtsilä-koncernen A/B, Dalsbruk Järnverk, Dalsbruk, Finland. (*Ingots, billets, bars, forgings and castings.*) (ÅBO.)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*) (SEATTLE.)

Washino Machine Co., Ltd., Imamura Plant, Aichi Prefecture, Japan. (*Castings.*) (KOBE.)

Watanabe Steel Works Co., Ltd., Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Welland Electric Steel Foundry Ltd., Welland, Ontario, Canada. (*Small castings.*) (TORONTO.)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*) (STOCKHOLM.)

Wood, Alan, Steel Company, Conshohocken and Ivy Rock, Pa., U.S.A. (*Blooms, billets and thin plates.*) (PHILADELPHIA.)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*) (ANTWERP.)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots and plates.*) (KOBE.)

Yawata Iron & Steel Manufacturing Co., Ltd., Yawata Works, Yawata, Japan,
Tobata Plant (*Plates.*) (SHIMONOSEKI.)
Yawata Plant (*Plates, sections, ingots and forgings.*) (SHIMONOSEKI.)

Yawata Steel Tube Co., Ltd., Tokyo, Japan. (*Rolling mills for weldless, rolled or drawn tubes.*) (YOKOHAMA.)

Yokoyama Engineering Co., Ltd., Oshima 2nd Works, Tokyo, Japan. (*Castings.*) (YOKOHAMA.)

Yonago Steel Works, Ltd., Yonago, Japan. (*Castings.*) (KOBE.)

Youngstown Sheet and Tube Company,
Brier Hill Works, Youngstown, Ohio, U.S.A.
Campbell Works, Campbell, Mahoning Co., Ohio, U.S.A. (*Ingots, and plates up to 12,5 mm. in thickness.*) (PITTSBURGH.)

Zaklady Budowy Przewodow i Armatury, Kielce, Poland. (*Castings.*) (KATOWICE.)

Zaklady Metalurgiczne, Poznan, "Pomet" Poznan, ul Krancowa 15, Poland. (*Castings.*) (GDANSK.)

Zaklady Urzadzen Technicznych "Zgoda", Swietochlowice, Poland. (*Forgings.*) (KATOWICE.)

Závody V. I. Lenina Plzen, národni podnik (V. I. Lenin Works Pilsen, National Corporation, formerly the Skoda Works, Pilsen), Plzeň, Czechoslovakia. (*Castings and forgings.*) (VIENNA.)

Zelezarna Jesenice, Jesenice, Yugoslavia. (SPLIT.)

Zelezarna Ravne, Ravne na Koroskem, Yugoslavia. (*Castings and forgings.*) (RIJEKA.)

Železárny a drátovny Bohumin, národni podnik (Iron Works and Wire Works Bohumin, National Corporation), Bohumin, Czechoslovakia. (*Small sections, bars and seamless tubes.*) (VIENNA.)

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*) (SPLIT.)

FIRMS IN COUNTRIES OTHER THAN GREAT BRITAIN AND IRELAND (ARRANGED ACCORDING TO SURVEYING DISTRICTS)

Åbo

Ahlström, A., Oy, Karhulan Tehtaat, Karhula Bruk, Karhula, Finland. (*Castings.*)

Fiskars Oy, Aktiebolag.
- Aminnefors Works, Aminnefors, Finland. (*Ingots, billets, bars and sections.*)
- Inha Works, Inha, Finland. (*Ingots and bars.*)

Lokomo Oy, Tampere, Finland. (*Ingots, forgings and castings.*)

Rosenlew, W., & Co., A/B Björneborgs Mekaniska Verkstad, Björneborg, Finland. (*Small castings.*)

Wärtsilä-koncernen A/B, Dalsbruks Järnverk, Dalsbruk, Finland. (*Ingots, billets, bars, forgings and castings.*)

Adelaide

Mason & Cox Ltd., Adelaide, S. Australia. (*Castings.*)

Amsterdam

Dikkers, G., & Co., N.V., Hengelo, Holland. (*Small castings.*)

Koninklijke Demka Staalfabrieken, N.V., Utrecht, Holland. (*Ingots, forgings, blooms, billets and castings; also rivet bars.*)

Koninklijke Nederlandsche Hoogovens & Staalfabrieken N.V. (Royal Netherlands Blast-Furnaces & Steel Works, Ltd.), Ymuiden, Holland. (*Plates and sections.*)

Antwerp

Allard, Usines & Aciéries, Société Anonyme, Mont-sur-Marchienne, near Charleroi. (*Castings.*)

Allard, Usines & Aciéries, Société Anonyme, Turnhout. (*Small castings.*)

"ARBED," Aciéries Réunies de Burbach-eich-Dudelange.
- Division de Dommeldange, Dommeldange, Luxembourg. (*Ingots, forgings and castings.*)
- Division de Belval, Esch-sur-Allzette, Luxembourg. (*Ingots, blooms, billets, bars and angle bars.*)
- Division d'Esch, Esch-sur-Allzette, Luxembourg. (*Rolling mills for bars and sections.*)

Baume, Société Anonyme des Forges et Laminoirs de, Haine St. Pierre. (*Ingots, bars and sections.*)

Boël, Usines Gustave, Soc. An., La Louvière. (*Ingots, forgings, castings, plates and bars.*)

Boom, Travaux Métalliques de, Société Anonyme, Boom. (*Small castings.*)

Charleroi, Societe Anonyme de la Fabrique de Fer de, Charleroi. (*Ingots and plates.*)

Clabecq, Société Anonyme Forges de, Clabecq, Belgium. (*Ingots, plates, bars and sections.*)

Cockerill-Ougrée, Société Anonyme, Seraing, Belgium.
- *Works:* Grivegnée. (*Ingots and plates.*)
- *Works:* Ougrée.
- *Works:* Seraing.

Antwerp—*continued*

Compagnie Générale des Aciers, Société Anonyme, Thy-le-Château, Belgium. (*Castings.*)

Gilson, Société Anonyme des Usines, Belgium.
- La Croyère (Bois d'Haine). (*Ingots, blooms, sections, rivet bars and forgings.*)
- Division "Baume", Haine St. Pierre. (*Ingots, bars and sections.*)

HADIR, Société des Hants Fourneaux et Aciéries de Differdange - St. Ingbert - Rumelange, Differdange Works, Luxembourg. (*Sections and bars.*)

Hainaut-Sambre, Société Métallurgiques, S.A., Couillet.
- Division de Couillet. (*Ingots, blooms, bars, forgings and castings.*)
- Division de Montignies et Chatelinlau. (*Rolling mill.*)

Haine St. Pierre et Lesquin, Aciéries de, Société Anonyme, Haine St. Pierre. (*Castings.*)

Henricot, Usines Emile, Court St. Etienne. (*Castings.*)

Jadot, Société Anonyme Etablissements, Beloeil, Belgium. (*Small castings.*)

Jemappes, Société Anonyme Forges et Laminoirs de, Jemappes, near Mons, Belgium. (*Ingots, blooms and bars.*)

La Brugeoise et Nivelles, Société Anonyme, St. Michel-lez-Bruges. (*Castings.*)

Leonard-Giot, Société Anonyme Usines & Aciéries Marchienne-au-Pont. (*Castings.*)

Les Acieries de la Meuse, S.A., Cheratte-lez-Liege, Belgium. (*Castings.*)

Providence, Société Anonyme des Forges de la, Marchienne-au-Pont, Belgium. (*Sections, bars, ingots and blooms.*)

Sambre, Aciéries & Minières de la,
- *Works :* Monceau-sur-Sambre. (*Sections, bars, billets and blooms.*)
- *Works :* Moncheret, near Acoz. (*Rolling mills for bars.*)

Société Belge Griffin S.A., Merxem, Antwerp. (*Castings.*)

Union des Aciéries, Société Anonyme, Marcinelle, Charleroi. (*Castings.*)

Wurth, Société Anonyme des Anciens Etablissements Paul, Luxembourg. (*Castings.*)

Augsburg

Eisen-und Stahlgiesserei Gebrüder Decker, Nürnberg, Germany. (*Electric steel castings.*)

Krauss-Maffei, A.G., München-Allach, Germany. (*Castings.*)

Streicher, M., Asperg/Württ, near Stuttgart, Germany. (*Castings.*)

Baltimore, Md.

Bethlehem Steel Co., Sparrows Point, Md., U.S.A. (*Plates.*)

Barcelona

Fundiciones Escora S.A., Pi y Margall, 2-Hospitalet de Llobregat, Barcelona, Spain. (*Castings.*)

Hierros y Aceros Industriales S.A., San Adrian de Besos, Barcelona, Spain. (*Small castings.*)

Industrias Mecanicas, Sociedad Anonima, Barcelona, Spain. (*Castings.*)

La Maquinista Terrestre y Maritima S.A., Barcelona, Spain. (*Castings and forgings.*)

Manufacturas de Acero S.A., Badalona, Barcelona, Spain. (*Small castings.*)

Material y Construcciones S.A., Barcelona, Spain. (*Castings.*)

Sucesora de Aceros Electricos S.A., Barcelona, Spain. (*Castings.*)

Bergen

Stavanger Electro-Staalverk A.S., Jorpeland, near Stavanger, Norway. (*Castings.*)

Berlin

Borsig A.G., Berlin-Tegel, Germany. (*Ingots, forgings and castings.*)

Bilbao

Babcock & Wilcox, Sociedad Española de Construcciones.
Head Office: Calle Ercilla 1, Bilbao.
Works: Galindo-San Salvador del Valle. (Vizcaya.) (*Castings, ingots and forgings.*)

Basconia, Compañia Anonima, Bilbao, Spain. (*Plates, sections and bars.*)

Compañia Auxiliar de Ferrocarriles, Beasain, Guipuzcoa, Spain. (*Small castings and forgings.*)

Deusto, Sociedad Anonima Talleres de, Deusto, Bilbao, Spain. (*Castings.*)

Echevarria, Sociedad Anonima, Bilbao, Spain. (*Small sections and bars, small forgings and ingots.*)

Echeverria, Patricio, S.A., Legazpia, Spain. (*Ingots, blooms and forgings.*)

Española de Construccion Naval, Sociedad.
Works: Reinosa, near Santander, Spain. (*Ingots, forgings, castings, plates and sections.*)
Works: Sesto, near Bilbao. (*Small castings, ingots and forgings.*)

Euskalduna, Compañia, Talleres de Elorrietta, Bilbao, Spain. (*Castings.*)

Fundiciones Echevarria S.A., Beasain, Guipuzcoa, (*Ingots and small rolled bars.*)

Fundiciones Ituarte S.A., Bilbao, Spain. (*Small castings.*)

Llodio, Aceros de, Ltda., Llodio, near Bilbao, Spain. (*Small castings, ingots, forgings and rolled bars.*)

Bilbao—*continued*

Luzuriaga, Victorio, S.L., Pasajes, Guipuzcoa, Spain. (*Castings.*)

Olarra S.A., Larrondo, Lujua Vizcaya, Spain. (*Ingots and rolled bars.*)

Trefilerias del Nervion S.A., Erandio, Bilbao, Spain. (*Ingots and small bars.*)

Vicinay S.A., Luchana-Bilbao, Bilbao, Spain. (*Ingots, castings and small forgings.*)

Vizcaya, Sociedad Altos Hornos de, Bilbao, Spain. (*Ingots, bars, sections, plates and forgings.*)

Bombay

Mukand Iron & Steel Works, Ltd., Kurla, Bombay 37, India. (*Castings.*)

Bordeaux

Compagnie des Ateliers et Forges de la Loire, Usine des Forges de l'Adour, Le Boucau, France. (*Plates and sections.*)

Société Anonyme d'Exploitation des Aciéries de Bordeaux, Pessac, Gironde, France. (*Castings.*)

Sud Ouest, Société des Forges et Aciéries du, Bordeaux (Gironde), France. (*Castings and forgings.*)

Bremen

Klöckner-Werke A.G., Hutte Bremen, Germany. (*Plates.*)

Brisbane

Walkers Ltd., Maryborough, Queensland, Australia. (*Forgings and castings.*)

Cadiz

Construcciones Agricolas, Sociedad Anonima de, (S.A.C.A.), Sevilla, Spain. (*Castings.*)

Española de Construccion Naval, Sociedad, San Carlos Factory, San Fernando, Cadiz, Spain. (*Forgings and castings.*)

Calcutta

Bhartia Electric Steel Co., Ltd., Calcutta, India. (*Castings.*)

Burn & Co., Ltd., Howrah, India. (*Small castings.*)

Indian Iron & Steel Co., Ltd., Burnpur Works, Burnpur, West Bengal, India. (*Sections and angles.*)

Indian Tube Company, (1953) Ltd., Jamshedpur, India. (*Seamless tubes.*)

Metal & Steel Factory, Ishapore, West Bengal, India. (*Ingots, blooms, billets and forgings.*)

National Iron & Steel Co., Ltd., Stephen House, Calcutta, 1, India. (*Castings.*)

Tata Iron & Steel Co., Ltd., Jamshedpur, India. (*Blooms, billets, bars, plates and sections.*)

Tata Locomotive & Engineering Co., Ltd., Jamshedpur 4, India. (*Castings.*)

Cleveland, O.

American Rolling Mill Co., Middletown, O., U.S.A. (*Castings and forgings.*)

Bethlehem Steel Co., Buffalo, N.Y., U.S.A.

Colorado Fuel & Iron Corporation, Minnequa Works, Pueblo, Colorado, U.S.A. (*Ingots, bars and small sections.*)

Erie Forge Co., Erie, Pa., U.S.A. (*Ingots, forgings and castings.*)

Falk Corporation, Milwaukee, Wis., U.S.A. (*Castings.*)

Finkl, A., & Sons Company, Chicago, Ill., U.S.A. (*Forgings.*)

Granite City Steel Co., Granite City, Ill., U.S.A.

Great Lakes Steel Corporation, Division of National Steel Corporation, Ecorse, Detroit 29, Michigan, U.S.A. (*Ingots, billets, bars, slabs, plate, blooms, sheet and coiled strip.*)

Inland Steel Co., Indiana Harbor, Ind., U.S.A. (*Ingots, blooms, billets and slabs.*)

Republic Steel Corporation, Cleveland, O., U.S.A.

Buffalo Plant, Buffalo, N.Y., U.S.A.

Central Alloy District, Massillon Plant, Massillon, O., U.S.A.

Chicago Plant, Chicago, Ill., U.S.A.

Works : 118th Street, Chicago. *Rolling mills :* East Chicago, Ind. (*Angles and bars.*)

Cleveland District, Cleveland, O., U.S.A.

Corrigan McKinney Plant. (*Ingots, blooms and billets.*)

Upson Nut Plant. (*Round and square bars.*)

United States Steel Company, Pittsburgh, Pa., U.S.A.

Gary Works, Gary, Ind. (*Billets, blooms, plates, sections, bars and forgings.*)

South Works, South Chicago, Ill. (*Plates, sections and bars.*)

Cologne (Köln)

Breitenbach, Ed., G.m.b.H., Weidenau-Sieg, Germany. (*Castings.*)

Hüttenwerke Siegerland A.G., Niederschelden, Germany. (*Ingots and slabs.*)

Klöckner - Mannstaedtwerke G.m.b.H., Troisdorf, Germany. (*Rolling mills for sections.*)

Schmidt & Clemens, Edelstahlwerk, Bergausen b/Engelskirchen Bez. Köln, Germany. (*Ingots, forgings, castings and bars.*)

Stahlwerke Röchling-Buderus A.G., Wetzlar, Germany. (*Ingots, blooms, billets, bars, forgings and plates.*)

Stahlwerke Südwestfalen, A.G., Werk Geisweid, Geisweid, Kries Siegen, Germany. (*Ingots, forgings, bars and thin plates.*)

Copenhagen

Burmeister & Wain's Maskin-og Skibsbyggeri, Aktieselskabet, Copenhagen, Denmark. (*Ingots, forgings and castings.*)

Danske, (Det), Staalvalsevaerk A/S., Frederiksvaerk, Denmark. (*Plates, sections and bars.*)

Copenhagen—*continued*

Frichs A/S, Aarhus, Denmark. (*Castings.*)

Helsingors Skibsvaerft-og Maskinbyggeri A/S., Aktieselskabet, Elsinore, Denmark. (*Ingots, forgings and castings.*)

Varde Staalvaerk, Varde, Denmark. (*Ingots and castings.*)

Dortmund

Deutsche Gerätebau G.m.b.H., Werk Stahl u. Eisengiesserei Schubeis, Schwelm, Germany. (*Castings.*)

Dortmund - Hoerder Hüttenunion A.G., Dortmund, Germany.

Dortmund-Hoerde Works. (*Ingots, plates, sections, bars, forgings and castings.*)

Dortmund Works. (*Bars, sections and forgings.*)

Eisenwerk Rödinghausen K. G., Lendringsen Krs. Iserlohn, Germany. (*Castings.*)

Eisenwerke Geweke, R. & C. R. Lange K.G., Hagen-Haspe, Germany. (*Electric steel castings.*)

Gussstahlwerk Carl Bönnhoff, Wetter/Ruhr, Germany. (*Castings.*)

Gussstahlwerk Witten A.G., Witten (Ruhr), Germany. (*Ingots, billets, sections, bars and forgings.*)

Gussstahlwerk Wittman A.G., Hagen-Haspe, Germany. (*Castings.*)

Hoesch-Westfalenhütte A.G., Dortmund, Germany. (*Ingots, billets, plates, bars and sections.*)

Klockner-Werke A.G., Hütte - Haspe, Hagen-Haspe, Germany. (*Ingots, plates, bars and sections.*)

Ruhrstahl A.G., Henrichshütte, Hattingen - Ruhr, Germany. (*Ingots, plates, forgings and castings.*)

Schutte, Meyer & Co., G.m.b.H., Letmathe, Westphalia, Germany. (*Small castings.*)

Stahlwerke Südwestfalen A.G., Werk Harkort Eicken, Hagen, Germany. (*Ingots, bars and forgings.*)

Durban

Mangolds Engineering, Port Elizabeth, South Africa. (*Small castings.*)

Dusseldorf

August Thyssen-Hütte A.G., Duisburg-Hamborn, Germany. (*Ingots, billets, sections and bars.*)

Bergische Stahlindustrie K.G., Remscheid, Germany. (*Castings.*)

Bochumer Verein für Gussstahlfabrikation A.G., Bochum, Germany. (*Ingots, forgings, castings and bars.*)

Deutsche Edelstahlwerke A.G., Krefeld, Germany. (*Ingots, castings, forgings and rolled materials.*)

Eisenwerke Mülheim-Meiderich Aktiengesellschaft, Mülheim-Ruhr, Germany. (*Castings.*)

Eschweiler Bergwerks - Verein, Hüttenbetriebe, Eschweiler-Aue, Germany. (*Ingots and seamless tubes.*)

Gussstahlwerk Gelsenkirchen A.G., Gelsenkirchen, Germany. (*Castings.*)

Dusseldorf—*continued*

Gussstahlwerk Oberkassel A.G., Düsseldorf-Oberkassel, Germany. (*Castings.*)

Gussstahlwerk Risch K.G., Bergisch-Gladbach, Germany. (*Electric steel castings.*)

Gutehoffnungshütte Sterkrade A.G., Werk Sterkrade, Oberhausen-Sterkrade, Germany. (*Forgings.*)

Hahn'sche Werke A.G., Duisburg-Grossenbaum, Germany. (*Bars and electric resistance welded tubes.*)

Hütten-und Bergwerke Rheinhausen A.G., Hüttenwerk Rheinhausen, Rheinhausen, Germany. (*Bars and sections only.*)

Hüttenwerk Oberhausen, A.G., Oberhausen, Germany. (*Ingots, plates, sections and bars.*)

Mannesmann Hüttenwerke A.G., Duisburg-Huckingen, Germany. (*Ingots, plates, sections and bars.*)

Phoenix-Rheinrohr A.G., Mülheim-Ruhr, Germany. (*Plates.*)

Stahl-u. Röhrenwerke Reisbolz A.G., Abt. Oberbilker Stahlwerk, Düsseldorf-Oberbilk, Germany. (*Ingots and forgings.*)

Stahlwerk Mark, Wengern A.G., Wengern-Ruhr, Germany. (*Ingots and castings.*)

Stahlwerke Bochum A.G., Bochum, Germany. (*Castings, forgings, rolled materials and plates.*)

Emden

Sande, Giesserei, Sande-Oldenburg, Germany. (*Castings.*)

Fremantle

Broken Hill Proprietary Co., Ltd., Rolling Mill at Kwinana, W. Australia. (*Small bars and sections.*)

Hadfields (W.A.) 1934 Ltd., Perth, W. Australia. (*Castings.*)

Gdansk

Huta Z.M.G.S., Elblag, Poland. (*Castings.*)

Zaklady Metalurgiczne Poznan, "Pomet", Poznan ul Krancowa 15, Poland. (*Castings.*)

Genoa

A.S.S.A. Acciaierie di Susa Società Anonima, Turin, Italy. *Head Office:* Turin. *Works:* Susa. (*Castings.*)

Ansaldo S.p.A., Stabilimento Fonderia di Ghisa e Metalli, Genova-Pegli, Italy. (*Forgings.*)

Bolzaneto, Acciaiera de Ferriero di, Genoa, Italy. *Works:* Genoa-Bolzaneto. (*Plates, sections and bars.*)

Cantieri del Tirreno, S.p.A., Riva Trigoso, Genoa, Italy. (*Small forgings.*)

Cornigliano S.p.A., Genoa, Italy. (*Ingots and plates.*)

Fabrica Italiana Tubi, Società Anonima, Sestri-Levante, Italy. (*Ingots, billets and weldless rolled and drawn tubes.*)

Genoa—*continued*

FIAT, Società per Azioni, Sezione Ferriere Piemontesi, Turin, Italy. (*Ingots, plates, sections; also seamless and welded tubes.*)

FIAT, Società per Azioni, Sezione Industrie Metallurgiche Acciaierie, Turin, Italy. (*Castings.*)

Fonderia Acciaieria Giovanni Mandelli, Turin, Italy. (*Small castings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A. *Head Office:* Genoa, Italy.

Stabilimento di-Genoa-Cornigliano. (*Ingots and plates.*)

Stabilimento di Genoa-Voltri. (*Rivets.*)

Stabilimento di Novi Ligure. (*Sections, bars and plates.*)

Nazionale "Cogne", S.p.A. *Head Office:* Turin, Italy. *Works:* Aosta. (*Ingots, forgings, plates, sections and bars.*)

Società Italiana Acciaierie Cornigliano. *Head Office:* Genoa, Italy. *Works:* Genoa-Cornigliano. (*Ingots, forgings, plates and castings.*)

Gijon

Astilleros y Talleres del Noroeste S.A., El Ferrol del Caudillo, Spain. (*Small forgings.*)

Duro-Felguera, Sociedad Metalúrgica, La Felguera, Asturias, Spain. (*Ingots, billets, castings, plates and sections.*)

Empresa Nacional Siderurgica, S.A., (ENSIDESA), Avilés, Spain. (*Ingots, slabs and billets for re-rolling.*)

Fabrica de Mieres, Mieres, Asturias, N. Spain. (*Sections, bars and plates up to 15 mm. in thickness.*)

"Santa Barbara", Sociedad Industrial Asturiana, Fábricas de Moreda y Gijon, Gijon, Spain. (*Rivet bars.*)

Trubia, Fábrica Nacional de, Trubia Asturias, Spain. (*Castings and forgings.*)

Gothenburg

Björneborgs Jernverks Aktiebolag, Björneborg, Sweden. (*Ingots and forgings.*)

Bofors Aktiebolaget, Bofors, Sweden. (*Ingots, forgings, castings and rolled bars.*)

Degerfors Jernverks Aktiebolag, Degerfors, Sweden. (*Ingots, plates, sections and bars.*)

Klafreströms Bruk, A/B, Klavreström, Sweden. (*Small castings.*)

Lesjöfors Aktiebolag, Lesjöfors, Sweden. (*Ingots and bars.*)

Motala Verkstad, A/B, Motala Verkstad, Sweden. (*Ingots, forgings, castings, sections and bars.*)

Uddeholms Aktiebolag, Uddeholm, Sweden.

Works at Storfors. (*Seamless tubes.*)

Works at Nykroppa. (*Ingots, forgings and bars.*)

Works at Hagfors. (*Castings.*)

Halifax, N.S.

Dominion Iron & Steel, Ltd., Sydney Works, Sydney, N.S. (*Ingots, billets and sections.*)

Dominion Steel & Coal Corporation Ltd., Trenton Works, Trenton, N.S. (*Forgings.*)

Maritime Steel and Foundries, Ltd., New Glasgow, N.S. (*Small castings.*)

Hamburg

Ellerbrock, Hans, Stahlgiesserei und Maschinenfabrik, Hamburg, Germany. (*Castings.*)

Hanover

Eisen-und Stahlwerk Pleissner G.m.b.H., Herzberg/Harz, Germany. (*Castings.*)

Huttenwerk Salzgitter, A.G., Salzgitter-Drütte, Germany. (*Ingots and plates.*)

Ilseder Hutte A.G., Peine, Germany. (*Ingots, billets, sections and bars.*)

Klockner - Werke A.G., Georgsmarienwerke, Osnabrück, Germany. (*Ingots, bars, forgings and castings.*)

MIAG (Muhlenbau und Industrie G.m.b.H.), Braunschweig, Germany. (*Castings.*)

Helsingfors

Vuoksenniska Oy, Aktiebolag, Imatra Iron Works, Imatra, Finland. (*Ingots, slabs, blooms and billets, bars and sections.*)

Istanbul

Makine ve Kimya Endustri, Celik Fabrikasi, Kirikkale, Turkey. (*Ingots, forgings, rolled sections and bars.*)

Turkiye Demir ve Celik Fabrikalari, Karabuk, Turkey. (*Ingots, plates, rolled sections and bars.*)

Katowice

Huta 1-Go Maja, Gliwice, Poland. (*Forgings.*)

Huta Baildon, Katowice, Poland. (*Ingots, forgings and bars.*)

Huta Batory, Chorzow-Batory, Poland. (*Forgings, plates and tubes.*)

Huta Bieruta, Czestochowa, Poland. (*Seamless tubes.*)

Huta Bobreck, Bytom, Poland. (*Ingots, slabs and blooms.*)

Huta Dzierzynskiego, Dabrowa Gornicza, Poland. (*Billets, sections and bars.*)

Huta Florian, Swietochlowice, Poland. (*Angles and bars.*)

Huta Jednosc, Siemianowice Slaskie, Poland. (*Ingots and seamless tubes.*)

Huta Kosciuszko, Chorzow, Poland. (*Billets, blooms, sections and rivet bars.*)

Huta Labedy, Labedy, Poland. (*Flats and sections.*)

Huta Lenina, Krakow, Poland. (*Ingots, slabs, plates up to 12 mm.*)

Katowice—*continued*

Huta Malapanew, Ozimek k/Opola, Poland. (*Castings.*)

Huta Nowotki, Ostrowiec Swietokrzyski, Poland. (*Sections.*)

Huta Pokoj, Nowy Bytom, Poland. (*Plates and sections.*)

Huta Sosnowiec, Sosnowiec, Poland. (*Castings and seamless tubes.*)

Huta Stalowa Wola, Stalowa Wola, Poland. (*Castings, forgings, plates and sections.*)

Huta Zawiercie, Zawiercie, Poland. (*Flats and bars.*)

Zaklady Budowy Przewodow i Armatury, Kielce, Poland. (*Castings.*)

Zaklady Urzadzen Technicznych "Zgoda", Swietochlowice, Poland. (*Forgings.*)

Kiel

Nordische Stahlwerke, Bach & Co., Neumünster, Germany. (*Castings.*)

Kobe

Aichi Steel Works Ltd.,
- Chita Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)
- Kariya Plant, Aichi Prefecture, Japan. (*Ingots and forgings.*)

Amagasaki Iron & Steel Mfg., Co., Ltd., Steel Plant, Amagasaki, Japan. (*Ingots, plates, sections and bars.*)

Daido Steel Co., Ltd.,
- Hoshizaki Works, Nagoya, Japan. (*Ingots and bars.*)
- Tsukiji Works, Nagoya, Japan. (*Ingots, forgings and castings.*)

Fuji Iron & Steel Co., Ltd., Hirohata Works, Hirohata, Himeji City, Japan. (*Ingots, billets and plates.*)

Fujinagata Shipbuilding Co., Ltd., Osaka, Japan. (*Castings and forgings.*)

Go Iron Works, Ltd., Ogaki Works, Ogaki, Japan. (*Small castings.*)

Hitachi Metal Industries Ltd., Yasugi Works, Yasugi, Japan. (*Ingots and bars.*)

Hitachi Shipbuilding & Engineering Co., Ltd.,
- Chikko Shipyard, Osaka, Japan. (*Castings and forgings.*)
- Innoshima Shipyard, Innoshima, Japan. (*Forgings and small castings.*)

Howa Machinery, Ltd., Aichi Prefecture, Japan. (*Castings*).

Iino Shipbuilding & Engineering Co., Ltd., Maizuru Dockyard, Maizuru, Japan. (*Forgings and castings.*)

Ishikawajima-Harima Heavy Industries Co., Ltd., Aioi Works, Aioi, Japan. (*Castings and forgings.*)

Izuo Chukosho Co., Ltd., Osaka, Japan. (*Castings.*)

K.K. Teikoku Kokan Seizosho, Osaka, Japan. (*Seamless tubes.*)

Kansai Tekko Co., Ltd., Amagasaki, Japan. (*Small forgings.*)

Kobe—*continued*

Kawasaki Dockyard Co., Ltd., Kobe, Japan. (*Forgings and castings.*)

Kawasaki Rolling Stock Mfg. Co., Ltd., Kobe, Japan. (*Castings.*)

Kawasaki Steel Corporation.
- Fukiai Works, Kobe, Japan. (*Plates.*)
- Hyogo Works, Kobe, Japan. (*Castings and forgings.*)
- Nishinomiya Works, Nishinomiya, Japan. (*Rolling mills for plates up to 14 mm. in thickness.*)

Kobe Steel Works, Ltd., Kobe, Japan. (*Castings, forgings and bars.*)

Kobe Steel Works, Ltd., Takasago Plant, Arai, Japan. (*Ingots, forgings and castings.*)

Kokko Steel Manufacturing Co., Ltd., Osaka, Japan. (*Angles, bars and castings.*)

Komatsu Manufacturing Co., Ltd.,
- Komatsu, Japan. (*Castings.*)
- Osaka Plant, Hirakata, Osaka Prefecture, Japan. (*Castings.*)

Kurimoto Iron Works Ltd., Kagaya Works, Osaka, Japan. (*Castings.*)

Maekawa Electric Steel Castings Co., Osaka, Japan. (*Castings.*)

Mitsubishi Heavy Industries Reorganized Ltd.,
- Kobe Shipyard & Engine Works, Kobe, Japan. (*Ingots, forgings and castings.*)
- Mihara Engineering Works, Mihara, Japan. (*Castings and forgings.*)

Mitsuboshi Iron Works Co., Ltd., Osaka, Japan. (*Small forgings.*)

Mitsui Shipbuilding & Engineering Co., Ltd., Tamano, Japan. (*Ingots, forgings and castings.*)

Mitsumoto Valve Manufacturing Co., Ltd., Domyoji, Osaka, Japan. (*Small castings.*)

Nakayama Steel Works, Osaka, Japan. (*Ingots, forgings, and plates up to 25 mm. in thickness.*)

Nippon Sharyo Seizo Kaisha Ltd., Nagoya, Japan. (*Castings.*)

Nippon Steel Foundry Co., Ltd., Osaka, Japan. (*Castings.*)

Nippon Tanko Co., Ltd., Amagasaki, Japan. (*Small forgings.*)

Nisshin Seiko Co., Ltd., No. 1 Shikama Plant, Himeji, Japan. (*Rolled bars.*)

Ohtani Heavy Industrial Co., Ltd.,
- Amagasaki Plant, Amagasaki, Japan. (*Plates up to 12,5 mm. in thickness.*)

Okamoto Iron Works Co., Kobe, Japan. (*Small forgings.*)

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka, Japan. (*Small castings.*)

Osaka Steel Casting Co., Ltd., Osaka, Japan. (*Small castings.*)

Kobe—*continued*

Sanyo Special Steel Co., Ltd., Himeji, Japan. (*Small forgings.*)

Sumitomo Electric Industries, Ltd., Itami Works, Itami, Hyogo Prefecture, Japan. (*Ingots and small bars.*)

Sumitomo Machinery Co., Ltd., Niihama, Japan. (*Castings.*)

Sumitomo Metal Industries, Ltd.
- Osaka Steel Works, Osaka, Japan. (*Castings and forgings.*)
- Steel Tube Works, Amagasaki, Japan. (*Ingots, forgings, small bars, sections and weldless tubes.*)
- Wakayama Steel Works, Wakayama, Japan. (*Small ingots, seamless tubes and electric resistance welded tubes.*)

Takada Steel Works, Ltd., Takada City, Nara Prefecture, Japan. (*Castings.*)

Toho Seiko Kabushiki Kaisha, Nagoya, Japan. (*Castings.*)

Tsukamoto Sogyo Co., Ltd., Osaka Works, Osaka, Japan. (*Castings.*)

Uraga Tamashima Diesel Kogyo K.K., Tamashima Factory, Tamashima, Japan. (*Small forgings.*)

Washino Machine Co., Ltd., Imamura Plant, Aichi Prefecture, Japan. (*Castings.*)

Yamato Steel Works, Ltd., Osaka, Japan. (*Ingots and plates.*)

Yonago Steel Works, Ltd., Yonago, Japan. (*Castings.*)

La Spezia

Faggian, Acciaierie Elettriche Pio, Soc. per Azioni, La Spezia. (*Small castings.*)

Leghorn

"ITALSIDER" Alti Forni e Acciaierie Ruinite Ilva e Cornigliano S.p.A., Stabilimento di Portovecchio di Piombino. (*Ingots, blooms, sections and bars.*)

Lisbon

Alves, Alfredo, & Cia. (Filhos), Amadora, Portugal. (*Castings.*)

Metalurgica Duarte Ferreira S.a.r.l., Tramagal, Portugal. (*Castings.*)

União Fabril, Companhia, Barreiro, Portugal. (*Castings.*)

Los Angeles

Bethlehem Pacific Coast Steel Corporation, Los Angeles 54, Cal., U.S.A. (*Round bars.*)

Columbia-Geneva Steel Division, United States Steel Corporation.
- Torrance Works, Torrance, Calif., U.S.A. (*Round bars and sections.*)
- Geneva Works, Provo, Utah, U.S.A. (*Plates.*)

Kaiser Steel Corporation, Fontana, Cal., U.S.A. (*Ingots and plates.*)

Los Angeles Steel Casting Co., Los Angeles, Cal., U.S.A. (*Castings.*)

Malmö

Anderson, Aktiebolaget Abjörn, Svedala, near Malmö, Sweden. (*Castings.*)

Kockums Jernverk, Kallinge, Sweden. (*Castings.*)

Mannheim

Dingler, Karcher & Cie., G.m.b.H., Saarländisches Stahlwerk, Worms/Rhein. (*Castings.*)

Schütze A.G., Ludwigshafen-Oggersheim, Germany. (*Electric steel castings.*)

Stahlwerk Mannheim A.G., Mannheim-Rheinau. (*Ingots, forgings and castings.*)

Marseilles

Aciéries du Furan, St. Etienne (Loire), France. (*Electric steel castings.*)

"Acieroy" Aciéries et Fonderies du Doubs, Société Anonyme, Sainte-Suzanne, near Montbéliard (Doubs), France. (*Small electric steel castings.*) (MARSEILLES.)

Aubert et Duval, Anciens Ets., Aciéries des Ancizes, Puy de Dôme. (*Ingots, rolled bars and forgings.*)

Compagnie des Ateliers et Forges de la Loire :

- Usines de l'Ondaine, Firmigny (Loire), France. (*Ingots, billets, blooms, bars, castings and forgings.*)
- Usines de St. Chamond (Loire), France. (*Forgings and plates.*)
- Usines de l'Ondaine, Unieux (Loire), France. (*Forgings.*)
- Usines de St. Etienne, St. Etienne (Loire), France. (*Plates.*)

Creusot, Société des Forges et Ateliers du, (S.F.A.C.), Usines Schneider, Le Creusot, France. (*Ingots, forgings, castings, plates and sections*).

Guerigny, Forges Nationales de la Chaussade à, (Nièvre), France. (*Ingots, bars and forgings.*)

Marrel Frères, Société Anonyme des Etablissements, Usine des Etaings, near Rive-de-Ciers (Loire), France. (*Ingots, forgings, plates and bars.*)

Méridionales, Fonderies, Marseilles, France. (*Castings.*)

Montluçon, Commentry, Société des Forges et Ateliers de, Usines St. Jacques, Montluçon (Allier), France. (*Castings, ingots, forgings, sheets and sections.*)

Provence, Fonderies et Aciéries de, Marseilles, France. (*Castings.*)

Saut-du-Tarn, Société Anonyme des Forges et Aciéries du, Saint-Juéry (Tarn), France. (*Castings.*)

Société Métallurgique d'Imphy.

- Aciéries d'Imphy (Nièvre), France. (*Ingots, forgings, bars and sections.*)
- Usine de Pamiers (Ariège), France. (*Castings and forgings.*)

Tamaris, Société des Ateliers et Fonderies des, Tamaris (Gard), France. (*Castings.*)

Teil, Fonderies et Aciéries du, Usine du Frayol, Le Teil (Ardèche), France. (*Small castings.*)

d'Ugine, Aciéries Electriques, Ugine (Savoie), France. (*Ingots, billets, bars, sections, castings and forgings.*)

Melbourne

K.M. Steel Products Pty., Ltd., Brooklyn, Melbourne. (*Ingots.*)

Steel Company of Australia, Pty., Ltd., Coburg, Melbourne. (*Castings.*)

Thompson's (Castlemaine) Ltd., Williamstown, Victoria. (*Castings.*)

Vickers, Ruwolt, Pty., Ltd., Richmond, Melbourne. (*Castings.*)

Metz (*Saarbrücken District*)

de Wendel et Cie., S/A, Hayange, Moselle, France.
Usine de Fenderie. (*Plates.*)
Usine de St. Jaques. (*Sections.*)

l'Est, Société des Aciers Fins de, Hagondange, Moselle, France. (*Ingots, blooms, billets, bars, plates and sheets.*)

Lorraine-Escaut S.A.,

- Usine de Longwy, Section Mont-St.-Martin, Mont-St.-Martin (Meurthe et Moselle). (*Sections and plates.*)
- Usine de Longwy, Section Senelle, Longwy-Bas (Meurthe et Moselle.) (*Ingots, blooms, bars and sections.*)
- Usine de Thionville, Thionville (Moselle). (*Forgings.*)

Pompey, Société des Aciéries de,

- Usine de Dieulouard, Meurthe et Moselle, France. (*Ingots, blooms, billets and bars.*)
- Usine de Pompey, Meurthe et Moselle, France. (*Ingots, plates, angles and round bars.*)

Société Lorraine de Laminage Continu, Sollac, B.P.13, Serémange, Moselle, France. (*Ingots, slabs and plates.*)

Union de Consommateurs de Produits Métallurgiques et Industriels, U.C.P.M.I., Forges et Aciéries d'Hagondange, Hagondange, Moselle, France. (*Blooms, billets, bars and sections.*)

Union Sidérurgique Lorraine, SIDELOR, Usine d'Homécourt, Meurthe et Moselle, France. (*Ingots, blooms, billets and plates.*)

- Usine de Micheville, Villerupt, Meurthe et Moselle, France. (*Ingots, blooms, billets, bars and sections.*)
- Usine de Rombas, Moselle, France. (*Ingots, blooms, billets, bars and sections.*)

Milan

Breda Fucine, S.p.A., Sesto San Giovanni, Milan. (*Castings and forgings.*)

Breda Siderurgica, S.p.A., Sesto San Giovanni, Milan. (*Ingots and sections.*)

Brescia, Acciaieria e Turbificio di, S.p.A., Brescia. (*Ingots, sections and bars, castings, weldless or water gas welded tubular materials.*)

Caleotto, Acciaieria e Ferriera del, S.p.A., Lecco. (*Ingots, castings, bars, small sections and small forgings.*)

Milan—*continued*

Cantieri Navali Riuniti. *Head Office:* Genoa. *Works:* Cantieri Navale ed Officine Meccaniche di Ancona. (*Small castings.*)

Ceretti, Pietro Maria, S.p.A., Ferriera Dell' Ossola-Villadossola. (*Castings.*)

Crucible Vanzetti S.p.A., Acciaierie, Milan. (*Castings.*)

Dalmine, S.p.A. *Head Office:* Milan.

Dalmine Costa Volpino, Bergamo. (*Seamless tubes*).

Dalmine Works, Bergamo. (*Ingots and seamless tubes.*)

Falck, Acciaierie e Ferriere Lombarde. *Head Office & Works:* Milan. (*Weldless rolled or drawn tubes.*)

Concordia Works, Sesto San Giovanni, Milan. (*Rolling mill for plates.*)

Unione Works, Sesto San Giovanni, Milan. (*Ingots, sections, bars, forgings and castings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Lovere. (*Sections, bars, castings and forgings.*)

Metallurgica Marcora, Busto Arsizio (Varese). (*Weldless rolled and drawn tubes.*)

Motomeccanica, S.p.A., Milan. (*Small castings.*)

Sesto San Giovanni, S.p.A., Acciaierie Elettriche di, S.p.A., Sesto San Giovanni, Milan. (*Castings.*)

S.I.S.M.A.—Società Industrie Siderurgiche Meccaniche & Affini, Villadossola (Novara). (*Rolled bars and rivets.*)

Società Metallurgica Vittorio Cobianchi S.p.A.
Head Office: Milan.
Works: Omegna (Novara.) (*Castings.*)

S.p.A., Fonderie Elettriche O. Pracchi, Milan. (*Small castings.*)

Stramezzi, P., & C., Acciaieria e Ferriera di Crema, Crema. (*Ingots, bars, small sections and rivets.*)

Tosi, Franco, S.p.A., Legnano. (*Forgings and castings.*)

Villa, Giovanni, S.p.A., Officine Meccaniche-Fucinati-Stampati, Milan. (*Forgings.*)

Mobile, Ala.

Kilby Steel Co., Furnace Division, Anniston, Ala., U.S.A. (*Ingots.*)

Republic Steel Corporation, Alabama City, Ala., U.S.A.

Tennessee Coal & Iron Division, United States Steel Corporation, Birmingham, Ala., U.S.A. *Works:* Ensley, Ala.; *Rolling mills and forgings:* Bessemer and Fairfield, Ala.

Montreal

Canadian Steel Foundries, Ltd., Longue Pointe, Montreal, P.Q., Canada. (*Castings.*)

Canadian Tube and Steel Products, Ltd., 5765, Hamilton Street, Montreal, P.Q., Canada. (*Angles, bars and rivets.*)

Canadian Unitcast-Steel, Ltd., Sherbrooke, P.Q., Canada. (*Castings.*)

Montreal—*continued*

Crucible Steel Company of Canada, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Lynn Macleod Metallurgy, Ltd., Thetford Mines, P.Q., Canada. (*Castings.*)

Manitoba Rolling Mill Co., Ltd., Selkirk, Manitoba, Canada. (*Billets, bars and sections.*)

Sorel Steel Foundries, Ltd., Sorel, P.Q., Canada. (*Castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada. *Works:* Montreal. (*Bars and angles, plates and billets.*)

Nantes

d'Hennebont, Forges, Hennebont, Morbihan, France. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines & Aciéries de, Usines de Saint Brieuc, Cotes-du-Nord. (*Small castings.*)

Naples

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Bagnoli. (*Ingots, sections and bars.*)

Meridionale, Acciaierie e Tubificio, S.p.A., Bari, Italy. (*Castings and weldless rolled or drawn tubes.*)

Officine Meccaniche e Fonderie Napoletane Naples, Italy. (*Castings.*)

"Terni" Società per l'Industria e l'Elettricha.
Works: Terni. (*Ingots, forgings, castings and plates.*)

Newcastle, N.S.W.

Broken Hill Proprietary Co., Ltd., Iron and Steel Works, Newcastle, N.S.W. (*Plates, bars, sections and castings.*)

Commonwealth Steel Co., Ltd., Waratah, Newcastle, N.S.W. (*Castings and forgings.*)

Newport News, Va.

Newport News Shipbuilding & Dry Dock Co., Newport News, Va., U.S.A. (*Castings and forgings.*)

Oslo

Christiania Spigerverk, Oslo. (*Ingots and bars, also rivet bars.*)

Drammens Jernstoberi & Mek-Verksted, A/S, Drammen. (*Small castings.*)

Norsk Jernverk, A/S, Mo-i-Rana. (*Electric steel ingots, billets, sections and bars.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Castings.*)

Strömmens Verksted, A/S, near Oslo. (*Castings.*)

Paris

Ferry-Captain & Cie, Société, Bussy, près Joinville (Haute Marne), France. (*Electric steel castings.*)

Gennevilliers, Aciéries de Gennevilliers, (Seine), France. (*Castings.*)

Paris-Seine, Fonderies et Aciéries de, Usine de la Folie, Avenue de Bobigny, Noisy-le-Sec (Seine), France. (*Castings.*)

Philadelphia, Pa.

Alan Wood Steel Company, Conshohocken and Ivy Rock, Pa., U.S.A. (*Blooms, billets and thin plates.*)

Atlantic Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*)

Bethlehem Steel Co., Bethlehem, Pa., U.S.A. (*Ingots, forgings, bars and sections.*)
Lebanon, Pa., U.S.A. (*Rolling mills for bars.*)
Steelton, Pa., U.S.A. (*Forgings and castings.*)

Birdsboro Corporation, Birdsboro, Pa., U.S.A. (*Castings.*)

Crucible Steel Castings Co., Lansdowne, Pa., U.S.A. (*Castings.*)

Dodge Steel Company, Tacony, Philadelphia, Pa., U.S.A. (*Small castings.*)

Donegal Steel Foundry Company, 601, East Market Street, Marietta, Pa., U.S.A. (*Castings.*)

General Steel Castings Corporation, Eddystone, Pa., U.S.A. (*Castings.*)

Lebanon Steel Foundry, Lebanon, Pa., U.S.A. (*Small castings.*)

Lukens Steel Company, Coatesville, Pa., U.S.A. (*Plates.*)

Midvale-Heppenstall Company, Nicetown, Philadelphia, Pa., U.S.A. (*Forgings.*)

Pencoyd Steel & Forge Corporation, 3720-40, Main Street, Philadelphia, Pa., U.S.A. (*Ingots and forgings.*)

Penn Steel Castings Co., Chester, Pa., U.S.A. (*Castings.*)

Pennsylvania Electric Steel Casting Co., Hamburg, Pa., U.S.A. (*Small castings.*)

Pennsylvania Forge, Division of Chemetron Corporation, Tacony, Philadelphia 35, Pa., U.S.A. (*Forgings.*)

Phoenix Steel Corporation.
Works: Claymont, Delaware, U.S.A. (*Plates.*)
Works: Plate Division, Harrisborg, Pa., U.S.A. (*Rolling mills.*)
Works: Structural Division, Phoenixville, Pa., U.S.A. (*Sections, bars and rotary forged seamless tubes.*)

Quaker Alloy Casting Co., Myerstown, Pa., U.S.A. (*Small castings.*)

Standard Steel Works Division of Baldwin-Lima-Hamilton Corp., Burnham, Mifflin County, Pa., U.S.A. (*Castings and forgings.*)

United States Steel Corporation, Fairless Works, Morrisville, Pa., U.S.A. (*Thin plates, bars and sections.*)

Pittsburgh, Pa.

Alco Products, Inc., Latrobe, Pa., U.S.A. (*Ingots and forgings.*)

Bethlehem Steel Co., Johnstown Plant, Johnstown, Pa., U.S.A.

Byers Company A.M. Admin. Office:- Clark Building, Pittsburgh 22, Pa., U.S.A.
Economy Pa., (*Plates, bars and ingots for forging.*)

Crucible Steel Company of America, 4 Gateway Center, P.O. Box 88, Pittsburgh 30, Pa., U.S.A.
Midland Plant, Midland, Pa. (*Ingots, slabs, billets, universal mill plates, hot rolled and cold drawn bars.*)

Jones & Laughlin Steel Corporation, Pittsburgh, Pa., U.S.A.

National Malleable & Steel Castings Co., Sharon, Pa., U.S.A. (*Castings.*)

Pittsburgh Steel Company, Pittsburgh 30, Pa., U.S.A.
Works: Monessen, Pa. (*Ingots, billets and slabs.*)
Works: Allenport, Pa. (*Rolling mills.*)

Republic Steel Corporation, Cleveland, O., U.S.A., Youngstown District, Youngstown, O., U.S.A.

United States Steel Corporation, Pittsburgh, Pa., U.S.A.
Clairton Works, Clairton, Pa. (*Ingots, blooms, bars and sections.*)
Duquesne Works, Duquesne, Pa. (*Ingots, billets, blooms and bars.*)
Homestead District Works, Pa., (*including* McKees Rock Works.) (*Ingots, billets, blooms, slabs, plates, sections and forgings.*)
Irvin Works, Dravosburg, Pa. (*Rolling mills for thin plates.*)
McDonald Mills, Youngstown. (*Rolling mills for bars and sections.*)
Ohio Works, Youngstown. (*Ingots, billets and blooms.*)

Youngstown Sheet and Tube Company,
Brier Hill Works, Youngstown, Ohio, U.S.A.
Campbell Works, Campbell, Mahoning Co., Ohio, U.S.A.
(*Ingots and plates up to* 12,5 *mm. in thickness.*)

Rijeka

Tvornica Dizalica "Vulkan", Rijeka II, Yugoslavia. (*Castings.*)

Zelezarna Ravne, Ravne na Koroskem, Yugoslavia. (*Castings and forgings.*)

Rio de Janeiro

Acos Villares S.A. Sao Caetano do Sul, Sao Paulo, Brazil. (*Castings, forgings, billets and bars.*)

Brasileira de Usinas Metalurgicas, The Companhia, Usina de Neves Sao Goncalo, Estado do Rio de Janeiro, Brazil. (*Ingots, sections and bars.*)

Companhia Siderurgica Nacional, Volta Redonda, Estado do Rio de Janeiro, Brazil. (*Plates and sections.*)

Mineracao Geral do Brazil, Lda., Sao Paulo, Brazil. (*Ingots and weldless tubes.*)

Rotterdam

Bakker N.V., Machinefabriek-Staalgieterij, Ridderkerk, Holland. (*Ingots and castings.*)

Rotterdamsche Droogdok Maatschappij, Rotterdam, Holland. (*Ingots, forgings and small castings.*)

Rouen

Société des Aciéries de Pompey, Usines du Manoir à Pitres (Eure), France. (*Castings.*)

Société Métallurgique de Normandie, Mondeville, France. (*Ingots, blooms, billets and bars.*)

Saarbrücken-Saar

"ARBED," Aciéries Réunies de Burbach - Eich - Dudelange,
Division de Burbach, Sarrebruck.
Burbach Works. (*Ingots, billets and sections.*)
Hostenbach Works. (*Plates.*)

Dingler, Karcher & Cie., G.m.b.H., Saarbrücken, Saar. (*Castings.*)

Röchling'sche Eisen-und Stahlwerke G.m.b.H., Völklingen (Saar). (*Castings, ingots, billets, bars and forgings.*)

Société Anonyme des Forges et Aciéries de Dilling, Dillingen, Sarre. (*Ingots and plates.*)

San Francisco, Cal.

Bethlehem Pacific Coast Steel Corporation, South San Francisco, Cal., U.S.A. (*Ingots, small sections and bars.*)

Enterprise Engine & Foundry Co., South City, Cal., U.S.A. (*Castings.*)

General Metals Corporation, Oakland, Cal., U.S.A. (*Castings.*)

Pacific States Steel Corporation, Niles, Cal., U.S.A. (*Ingots, sections and bars.*)

Pacific Steel Castings Co., Berkeley, Cal., U.S.A. (*Castings.*)

Seattle, Wash.

Bethlehem Pacific Coast Steel Corporation, Seattle, Wash., U.S.A. (*Sections and bars.*)

Isaacson Iron Works, P.O. Box 3028, Seattle, Wash., U.S.A. (*Ingots.*)

Olympic Steel Works, Seattle, Wash., U.S.A. (*Castings.*)

Washington Iron Works, Seattle, Wash., U.S.A. (*Castings.*)

Shimonoseki

Amagasaki Iron & Steel Manufacturing Co., Ltd., Kure Steel Works, Kure, Japan. (*Ingots and castings.*)

Hitachi Ltd., Kasado Works, Kudamatsu, Japan. (*Castings and forgings.*)

Shimonoseki—*continued*

Hitachi Metal Industries Ltd., Tobata Works, Tobata, Japan. (*Castings.*)

Japan Steel Works Ltd., Hiroshima Works, Hiroshima, Japan. (*Forgings and castings.*)

Kotobuki Kogyo Co., Ltd., Hiro Works, Kure, Japan. (*Castings.*)

Kure Shipbuilding & Engineering Co., Ltd., Kure, Japan. (*Small forgings.*)

Matsuya Kogyo Co., Ltd., Fukuoka, Japan. (*Small forgings.*)

Mitsubishi Shipbuilding & Engineering Co., Ltd.,
Hiroshima Works, Hiroshima, Japan. (*Ingots, castings and small forgings.*)
Hiroshima Precision Machine Works, Hiroshima, Japan. (*Small forgings.*)
Nagasaki Works, Nagasaki, Japan. (*Castings and small forgings.*)
Shimonoseki Works, Shimonoseki, Japan. (*Small forgings.*)

Mitsubishi Steel Manufacturing Co., Ltd., Nagasaki Works, Japan. (*Ingots, blooms, plates, forgings and castings.*)

Mitsui Miike Machinery Co., Ltd., Miike Works, Omutashi, Japan. (*Castings.*)

Nisshin Steel Works, Ltd., Kure Works, Kure, Japan. (*Ingots, blooms, billets and strip.*)

Okano Valve Manufacturing Co., Ltd., Moji. *Works:* Yukuhashi, Japan. (*Small castings.*)

Osaka Steel Tube Co., Ltd., Sasebo Works, Sasebo, Japan. (*Seamless tubes.*)

Sasebo Ship Industry Co., Ltd., Sasebo, Japan. (*Castings and forgings.*)

Sumitomo Metal Industries, Ltd. Kokura Steel Works, Kokura, Japan. (*Ingots, billets, bars and sections.*)

Ube Industries, Ltd., Ube Iron Works, Ube, Japan. (*Ingots, forgings and castings.*)

Yawata Iron and Steel Manufacturing Co., Ltd., Yawata Works, Yawata, Japan.
Tobata Plant. (*Plates.*)
Yawata Plant. (*Plates, sections, ingots and forgings.*)

Split

Titovi Zavodi Litostroj, Ljubljana, Yugoslavia. (*Castings.*)

Zelezarna Jesenice, Jesenice, Yugoslavia.

Zeljezara Zenica, Zenica, Yugoslavia. (*Billets, bars, sections and forgings.*)

Stockholm

Avesta Jernverks Aktiebolag, Avesta, Sweden. (*Plates, sections and castings; also high pressure air receivers.*)

Boxholms A/B., Boxholm, Sweden. (*Ingots, rolled slabs, blooms, billets, sections and bars.*)

Stockholm—*continued*

Fagersta Bruks Aktiebolag, Fagersta, Sweden (Bruks-koncernen).

Works: Fagersta. (*Blooms, billets, forgings, rolled bars and electric resistance welded tubes.*)

Works: Forsbacka. (*Blooms, billets, forged and rolled bars.*)

Works: Horndal. (*Bars and sections.*)

Works: Osterbybruk. (*Castings, forgings and rolling mill for bars.*)

Hallstahammar Aktiebolag, Hallstahammar, Sweden. (*Bars.*)

Kanthal, A/B, Hallstahammer, Sweden. (*Ingots, billets, bars and castings.*)

Kohlswa Jernverks Aktiebolag. (*Ingots, forgings and castings.*)

Larssons A/B, P. S., Gjuteri & Aduceringsverk, Eskilduna, Sweden. (*Castings.*)

Nordiska Armaturfabrikerna, A/B, Linköping, Sweden. (*Castings.*)

Norrbottens Järnverk Aktiebolag, Lulea, Sweden. (*Ingots, slabs, blooms and billets, bars and sections.*)

Oxelosunds Jarnverk, Oxelosund, Sweden. (*Ingots, rolled slabs and plates.*)

Ramnas Bruks Aktiebolag, Ramnas, Sweden. (*Rolling mills for bars.*)

SKF, Hofors Bruk, Hofors, Sweden. (*Billets, bars, forgings and thick walled tubes.*)

Sandvikens Jernverks Aktiebolag, Sandviken, Sweden. (*Ingots, forgings, and tubes.*)

Smedjebackens Valsverks Aktiebolag, Smedjebacken, Sweden. (*Sections and castings.*)

Stål och Maskinaktiebolaget, Upsala, Sweden. (*Ingots.*)

Stora Kopparbergs Bergslags Aktiebolag, Falun, Sweden.

Works: Domnarfvet. (*Castings, ingots, sections and plates.*)

Works: Söderfors. (*Forgings, bars and sections.*)

Surahammars Bruks Aktiebolag, Surahammar, Sweden. (*Plates, forgings and castings.*)

Svenska Jarnvagsverkstaderna, A/B, Linköping, Sweden. (*Castings.*)

Svenska Kullagerfabriken, Aktiebolaget, Katrineholm, Sweden. (*Castings.*)

Wikmanshytte Bruks A/B, Wikmanshyttan, Sweden. (*Forgings, bars and sections.*)

Sydney, N.S.W.

Australian Iron & Steel, Pty., Ltd., Port Kembla, N.S.W. (*Plates, bars, sections and forgings.*)

Bradford, Kendall, Ltd., Alexandria, Sydney, N.S.W. (*Castings.*)

Hadfields Steel Works, Ltd., Alexandria, Sydney, N.S.W. (*Castings and forgings.*)

Industrial Steels, Ltd., Lidcombe, Sydney, N.S.W. (*Castings.*)

Talcahuano

Pacifico, Compania de Acero del, S.A., Talcahuano, Chile. (*Ingots, plates, bars and sections.*)

Toronto, Ontario

Algoma Steel Corporation, Ltd., Sault St. Marie, Ontario, Canada. (*Billets, bars, angles and plates.*)

Atlas Steels Ltd., Welland, Ontario, Canada. (*Ingots and bars.*)

Burlington Steel Co., Ltd., Hamilton, Ontario, Canada. (*Small sections and bars.*)

Canada Foundries & Forgings, Ltd., Welland, Ontario, Canada. (*Forgings.*)

Dominion Foundries & Steel, Ltd., Hamilton, Ontario, Canada. (*Ingots, plates and castings.*)

Steel Company of Canada, Hamilton, Ontario, Canada. (*Bars and angles, plates and billets.*)

Welland Electric Steel Foundry, Ltd., Welland, Ontario, Canada. (*Small castings.*)

Trieste

Bertoli fu Rudolfo, Società Anonima Officine Fratelli, Udine, Italy. (*Castings, forgings, bars and sections.*)

Gorizia, Società Anonima Fonderie Officine di, Gorizia, Italy. (*Small castings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Servola. (*Ingots and plates.*)

O.R.I.O.N. S.p.A., Petro-Chimica Dal Pozzo, Porto Industriale, Trieste, Italy. (*Forgings and castings.*)

S.A.F.A.U. Ferriere Acciaierie di Udine, Udine, Italy. (*Forgings and castings.*)

Valencia

"ELCANO", Empresa Nacional, Factoria de Manises, Valencia, Spain. (*Castings and forgings.*)

Vizcaya, Altos Hornos de, S.A., Fabrica de Sagunto, Sagunto, Spain. (*Ingots, plates, bars and sections.*)

Valenciennes

Blanc-Misseron, Société Francaise des Acieries de, Quievrechain, Nord, France. (*Ingots and castings.*)

Chiers, Société des Hauts-Fourneaux de la, Forges de Vireux Molhain, Vireux, Ardennes, France. (*Plates, bars and sections.*)

Compagnie des Ateliers et Forges de la Loire, Usine des dunes, Malo les Bains, (Nord). (*Ingots, billets, blooms, bars and forgings.*)

Constructions Electriques de Jeumont, Forges et Ateliers de, Jeumont (Nord), France. (*Castings.*)

Fives-Lille-Cail, Société de,

Usine de Fives, Lille (Nord), France. (*Forgings.*)

Usine de Denain, Denain (Nord), France. (*Castings, ingots, forgings, blooms, bars and sheets.*)

Valenciennes—*continued*

Hachette & Driout, S.A., des Anciens Etablissements, St. Dizier, Hte. Marne, France. (*Castings.*)

Haine - St. - Pierre et Lesquin, Aciéries de, Société Anonyme, Lesquin-lez-Lille (Nord), France. (*Castings.*)

d'Hirson S.A., Aciéries, Hirson, Aisne, France. (*Castings.*)

Laminoirs, Société Anonyme des, Hauts-Fourneaux, Forges et Fonderies, de la Providence, Hautmont (Nord), France. (*Ingots, plates and sections.*)

Lorraine-Escaut S.A.,
Département Tubes, Usine d'Anzin, Anzin (Nord), France. (*Ingots and weldless rolled or drawn tubes.*)
Usine de Sedan, Sedan (Ardennes). (*Plates.*)

Marpent, Aciéries & Ateliers de Construction de, Marpent, (Nord), France. (*Castings.*)

Marquise, Usines Métallurgiques de, Rinxent, Pas-de-Calais. (*Castings.*)

Maubeuge, Société Anonyme de la Fabrique de Fer de, Louvroil (Nord). (*Ingots and plates.*)

Maurice Dembiermont & Cie., Hautmont (Nord), France. (*Forgings.*)

Meuse, Societe Metallurgique de la, Forges et Acieries de Stenay, Stenay, Meuse. (*Small castings.*)

Paris et d'Outreau, Aciéries de, Société Anonyme, Usine d'Outreau, Pas de Calais. (*Castings.*)

Sambre et Meuse, Société Anonyme des Usines et Aciéries de, Usines de Feignies, Feignies (Nord). (*Castings.*)

Union Siderurgique du Nord de la France.
USINOR GROUPE A.
Usines de Denain, Denain (Nord). (*Ingots, plates, sections and castings.*)
USINOR GROUPE B.
Usines de Louvroil-Hautmont, Hautmont (Nord). (*Ingots, bars and sections.*)
Usines de Valenciennes, Valenciennes (Nord). (*Ingots, forgings, blooms, bars and sections.*)

Vallourec, Société, Usine d'Aulnoye, Aulnoye (Nord), France. (*Weldless rolled and drawn tubes.*)

Vancouver, B.C.

A.1. Iron & Steel Foundry Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Canadian Sumner Iron Works Ltd., Vancouver, B.C., Canada. (*Small castings.*)

Victoria Machinery Depot Co., Ltd., Victoria, B.C., Canada. (*Castings.*)

Venice (Mestre)

Bolzano, S.p.A., Acciaierie di, Bolzano. (*Ingots, billets, bars and forgings.*)

Gresele, Acciaierie Valbruna di Ernesto, Vicenza. (*Castings, bars, sections and forgings.*)

"ITALSIDER" Alti Forni e Acciaierie Riunite Ilva e Cornigliano S.p.A., Stabilimento di Marghera. (*Castings, also rolling mills for small sections and bars.*)

Vereeniging

Dunswart Iron & Steel Works, Ltd., Benoni, South Africa. (*Castings, ingots, billets, and small sections.*)

Scaw Metals, Ltd., Union Junction, Transvaal, S. Africa. (*Rivet bars, small rolled sections and castings.*)

South African Iron & Steel Industrial Corporation, Ltd.,
"Iscor" Works, Pretoria, Transvaal, S. Africa. (*Ingots, billets, sections and thin plates up to 9,5 mm. thick.*)
"Iscor" Works, Vanderbijl Park, Transvaal, S. Africa. (*Ingots, billets, slabs and plates.*)

Union Steel Corporation of South Africa, Ltd., "Usco" Steel Works, Vereeniging, Transvaal, S. Africa. (*Ingots, billets, small sections, castings and rivet bars.*)

Vanderbijl Engineering Corporation, Ltd., Vanderbijl Park, Transvaal, South Africa. (*Castings.*)

Vienna

WORKS IN AUSTRIA

Böhler, Gebr., & Co., Aktiengesellschaft, Vienna.
Works: Kapfenberg, Styria. (*Ingots, castings, forgings, bars and plates.*)
Works: Bruckbach, Low Austria. (*Rolling mills for sections and bars.*)

Klinger, Rich., Aktiengesellschaft, Gumpoldskirchen, near Vienna. (*Small castings.*)

Oesterreichisch - Alpine Montangesellschaft, Vienna.
Works : Donawitz, Styria. (*Plates and sections.*)
Works : Kindberg, Styria. (*Rolling mills for small sections and bars.*)
Works: Traisen, Low Austria. (*Castings.*)
Works : Wördern, Low Austria. (*Ingots.*)
Works: Zeltweg, Styria. (*Forged bars.*)

Schoeller-Bleckmann Stahlwerke A.G., Vienna.
Works: Muerzzuschlag-Hoenigsberg, Styria. (*Bars.*)
Works : Ternitz, Low Austria. (*Castings, forgings and bars.*)

Steirische Gusstahlwerke, A.G., Vienna.
Works: Judenburg, Styria. (*Forgings and bars.*)

Vereinigte Oesterreichische Eisen-und-Stahlwerke A.G.
Works: Liezen, Styria. (*Ingots for forgings, castings.*)
Works: Linz a.d. Donau, Upper Austria. (*Plates, forgings and castings.*)

Waagner-Biro Aktiengesellschaft, Vienna, Austria.
Works: Werk C., Vienna. (*Castings.*)

WORKS IN CZECHOSLOVAKIA

Nová hut Klementa Gottwalda, národni podnik (New Metallurgical Works of Klement Gottwald, National Corporation), Ostrava - Kunčice. (*Ingots and forgings.*)

Třinecké železárny velké Řijnové socialistické revoluce, národni podnik (Třinec Iron Works Great Socialistic October Revolution National Corporation), Třinec. (*Ingots, sections, bars and castings.*)

Vienna—*continued*

Vítkovické Železárny Klementa Gottwalda, národni podnik (The Vitkovice Steel Works Klement Gottwald, National Corporation), Ostrava 10. (*Castings, forgings, plates, sections, bars and seamless tubes.*)

Závody V. I. Lenina Plzeň, národni podnik (V. I. Lenin Works Pilsen, National Corporation, formerly the Skoda Works, Pilsen), Plzeň. (*Castings and forgings.*)

Zelezárny a drátovny Bohumin, národni podnik (Iron Works & Wire Works Bohumin, National Corporation), Bohumin, Czechoslovakia. (*Small sections, bars and seamless tubes.*)

Works in Hungary

Ganz-Mavag Mozdony Vagon es Gepgyar, Budapest. (*Castings and forgings.*)

K.G.M. Altalanos Gepipari Igazgatosag, Budapest.
Works: Kobanyai Vas-es Acelontode, Budapest. (*Castings.*) (Vienna.)

K.G.M. Jarmuipari Igazgatosag, Budapest.
Works: Wilhelm Pieck Vagon es Gepgyar, Gyor. (*Castings.*)

K.G.M. Vaskohászati Igazgatóság, Budapest.
Works: Lenin Kohászati Müvek, Miskolc-Diósgyör. (*Ingots, slabs, sections, bars, castings and forgings.*)
Works: Lörinci Hengermü, Budapest. (*Rolling mill for plates.*)
Works: Ozdi Kohászati, Uzemek, Ozd. (*Ingots, slabs, plates, sections and bars.*)

Vigo

Aceros del Zarzo S.A. (Adeza), Cabanas, Puentedeume (La Coruna), Spain. (*Ingots and small castings.*)

Astilleros y Talleres del Noroeste S.A., El Ferrol de Caudillo, Spain. (*Small forgings.*)

Empresa Nacional Bazan, El Ferrol del Caudillo, Spain. (*Castings.*)

Whyalla

Broken Hill Proprietary Co., Ltd., Steel Foundry, Whyalla, S. Australia. (*Castings.*)

Winterthur

de Roll, Société des Usines de Louis, Gerlafingen, Switzerland. (*Ingots, round bars and forgings.*)

Fischer, Société Anonyme des Aciéries ci-devant Georges, Schaffhouse, Switzerland. (*Castings.*)

Sulzer Frères, Société Anonyme, Winterthur, Switzerland. (*Castings.*)

Yokohama

Ando Iron Works Co., Ltd., Tokyo, Japan. (*Small forgings.*)

Azuma Steel Works Ltd.,
Azuma Plant, Tokyo, Japan. (*Ingots for plate.*)
Senju Plant, Tokyo, Japan. (*Rolling mills for plates.*)

Yokohama—*continued*

Date Seiko Co., Ltd., Tokyo, Japan. (*Castings.*)

Fuji Iron & Steel Co., Ltd.,
Works at Kamaishi, Japan. (*Sections and bars.*)
Works at Kawasaki, Japan. (*Rolling mills for strips for electric resistance welded tubes.*)
Works at Muroran, Japan. (*Billets, sections and bars.*)

Hakodate Dock Co., Ltd., Hakodate Shipyard, Hakodate, Japan. (*Small castings and forgings.*)

Hatakeyama Iron Works Co., Ltd., Komatsugawa Works, Tokyo, Japan. (*Small forgings.*)

Hitachi Ltd.,
Hitachi Works, Hitachi, Japan. (*Castings.*)
Mito Works, Katsutashi, Ibaragi-ken. (*Ingots, forgings and castings.*)

Hokuriku Kogyo Co., Ltd., Sanjo Plant, Sanjo, Niigata Prefecture, Japan. (*Small forgings.*)

Ishikawajima Heavy Industries Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*)

Ishikawajima Shibaura Turbine Co., Ltd., Tokyo, Tsurumi Plant, Yokohama, Japan. (*Small castings.*)

Japan Special Steel Co., Ltd., Tokyo, Japan. (*Forgings.*)

Japan Steel Works Ltd., Muroran Works, Muroran, Japan. (*Ingots, forgings, castings and plates.*)

Kakegawa Endo Iron Works Co., Ltd., Kakegawa, Japan. (*Forgings.*)

Kanto Special Steel Works Ltd., Fujisawa, Kanagawa Pref., Japan. (*Forgings.*)

Kanto Steel Co., Ltd., Shibukawa Works, Shibukawa, Japan. (*Ingots, small forgings and bars.*)

Kawaguchi Kinzoku Kogyo Kabushiki Kaisha, Kawaguchi, Japan. (*Castings.*)

Kawasaki Steel Corporation, Chiba Works, Chiba, Japan. (*Slabs for plates.*)

Kureha Seitetsu Co., Ltd., Toyama, Japan. (*Ingots.*)

Mitsubishi Kozai Kabushiki Kaisha, Tokyo, Japan.
Main Works. (*Rolling mills for billets and bars.*)
Fukagawa Works. (*Billets and bars.*)
Hirota Works. (*Ingots.*)

Mitsubishi Nippon Heavy Industries, Ltd., Yokohama Shipyard and Engine Works, Yokohama, Japan. (*Ingots, blooms, small forgings and castings.*)

Nihon Cast Steel Co., Ltd., Tokyo, Japan. (*Ingots, forgings and castings.*)

Niigata Engineering Co., Ltd., Niigata, Japan. (*Castings, ingots and forgings.*)

Nippon Chuzo Kabushiki Kaisha, Kawasaki, Japan. (*Ingots and castings.*)

Nippon Kokan Kabushiki Kaisha,
Asano Dockyard, Yokohama, Japan. (*Forgings.*)
Kawasaki Iron Works, Kawasaki, Japan. (*Tubes, bars and sections.*)
Mizue Ironworks, Kawasaki, Japan. (*Plates up to ½-inch in thickness.*)
Tsurumi Iron Works, Tsurumi, Yokohama, Japan. (*Plates.*)

Yokohama—*continued*

Nippon Stainless Steel Co., Ltd., Naoetsu Works, Niigata, Japan. (*Ingots, forgings and castings.*)

Nippon Yakin Kogyo Co., Ltd., Kawasaki, Japan. (*Ingots, forgings, bars and sheets.*)

Nisso Steel Manufacturing Co., Ltd.,

Naoetsu Factory, Naoetsu, Niigata, Japan. (*Ingots.*)

Oshima Plant, Tokyo, Japan. (*Castings, plates and ingots for forging and plate.*)

Toyama Factory, Toyama City, Japan. (*Ingots and forgings.*)

Nittoku Metal Industry Co., Ltd., Tokyo, Japan. (*Small forgings.*)

Riken Tanzo Co., Ltd., Maebashi Plant, Maebashi, Japan. (*Small forgings.*)

Shimizu Tanzo Kabushiki Kaisha, Tokyo, Japan. (*Forgings.*)

Shin Nippon Tanko K.K., Kawasaki, Japan. (*Small forgings.*)

Sunnan Iron Works Co., Ltd., Yaizu, Japan. (*Forgings.*)

Taira Steel Works, Osaka Shipbuilding Co., Ltd., Taira, Fukushima Prefecture, Japan. (*Castings.*)

Takasaki Metal Industry Co., Ltd., Takasaki Plant, Takasaki, Japan. (*Small castings.*)

Yokohama—*continued*

Tohoku Special Steel Works Ltd., Sendai, Japan. (*Ingots small forgings, billets and bars.*)

Tokushu Seiko (Special Steel Mfg.) Co., Ltd., Kawasaki Works, Kawasaki, Japan. (*Ingots, forgings and bars.*)

Tokyo Kikai Kabushiki Kaisha, Oshima Cast Steel Works, Tokyo, Japan. (*Castings.*)

Tokyo Steel Casting Co., Ltd., Tokyo, Japan. (*Castings.*)

Tokyo Tankosho Co., Ltd., Kawasaki Factory, Kawasaki, Japan. (*Small forgings.*)

Toshiba Steel Co., Ltd., Tokyo, Japan. (*Castings, small forgings, sections and ingots for forging and plates.*)

Toto Steel Manufacturing Co., Ltd.,

Tokyo Plant, Tokyo, Japan. (*Sections.*)

Chigasaki Foundry, Chigasaki, Japan. (*Ingots for forging, castings.*)

Uraga Shipbuilding Yard, Uraga Dock Co., Ltd., Yokosuka, Japan. (*Castings and small forgings.*)

Watanabe Steel Works Co., Ltd., Tokyo, Japan. (*Castings.*)

Yawata Steel Tube Co., Ltd., Tokyo Japan. (*Rolling mills for weldless rolled or drawn tubes.*)

Yokoyama Engineering Co., Ltd., Oshima 2nd Works, Tokyo, Japan. (*Castings.*)

MANUFACTURERS OF ALUMINIUM ALLOYS

The following establishments have complied with the conditions contained in P 16 to P 18 of the Rules and are recognised by the Committee for the manufacture of aluminium alloys for shipbuilding purposes.

United Kingdom

Alcan Industries Ltd., Newport, Mon. (*Aluminium alloys and products.*)

Almin Ltd.
- International Alloys Ltd., Aylesbury, Bucks. (*Aluminium alloys.*)
- Southern Forge Ltd., Langley, Bucks. (*Aluminium alloy products.*)

Aluminium Wire & Cable Co., Ltd., Port Tennant, Swansea. (*Aluminium alloys and products.*)

Birmetals Ltd., Quinton, Birmingham. (*Aluminium alloys and products.*)

James Booth Aluminium Ltd., Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Falkirk. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Milton, Staffs. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Redditch Works, Birmingham. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Rheola Works, South Wales. (*Aluminium alloys and products.*)

British Aluminium Co., Ltd., Tyseley Works, Birmingham. (*Aluminium alloy products.*)

British Aluminium Co., Ltd., Bank Quay, Warrington. (*Aluminium alloys and products.*)

High Duty Alloys Ltd., Winscales, Workington. (*Aluminium alloys and products.*)

Imperial Aluminium Co., Ltd., Waunarlwydd, near Swansea. (*Aluminium alloys and products.*)

E. & E. Kaye, Ltd., Enfield, Middlesex. (*Aluminium alloys and products.*)

Northern Aluminium Co., Ltd., Banbury. (*Aluminium alloys and products.*)

Austria

Vereinigte Metallwerke Ranshofen-Berndorf A.G., Braunau am Inn. (*Aluminium alloys and products.*)

Belgium

Ateliers Remi Claeys Lichtervelde. (*Aluminium alloy products.*)

Laminoirs de l'Escaut, Burcht. (*Aluminium alloy products.*)

S.A. Sidal, Société de L'Aluminium, Duffel. (*Aluminium alloys and products.*)

Canada

Aluminum Company of Canada, Ltd. (No. 1 Plant), Shawinigan Falls, Quebec. (*Aluminium alloy products.*)

Aluminum Company of Canada, Ltd., Etobicoke Works, Long Branch, Ont. (*Aluminium alloy products.*)

Canada—*continued.*

Aluminum Company of Canada, Ltd., Kingston, Ont. (*Aluminium alloys and products.*)

R. D. Werner Co. (Canada), Ltd., Oshawa, Ont. (*Aluminium alloys and products.*)

France

Compagnie Générale du Duralumin et du Cuivre (Cegedur).
- Blanc-Mesnil. (*Aluminium alloys and products.*)
- Chambery (Savoie). (*Aluminium alloy products.*)
- Faremoutiers (Seine & Marne). (*Aluminium alloys and products.*)
- Issoire (Puy de Dome). (*Aluminium alloys and products.*)
- Rive de Gier (Loire). (*Aluminium alloy products.*)

Tréfileries et Laminoirs du Havre, Montreuil-Belfroy. (*Aluminium alloy products.*)

Germany

Aluminiumwalzwerke Singen G.m.b.H., Singen (Hohentwiel). (*Aluminium alloys and products.*)

Otto Fuchs, Meinerzhagen. (*Aluminium alloys and products.*)

Osnabrücker Kupfer - und Drahtwerk, Osnabrück. (*Aluminium alloys and products.*)

Vereinigte Deutsche Metallwerke A.G., Frankfurt-Heddernheim. (*Aluminium alloys and products.*)

Vereinigte Leichtmetallwerke G.m.b.H., Bonn. (*Aluminium alloys and products.*)

Vereinigte Leichtmetallwerke G.m.b.H., Hanover. (*Aluminium alloys and products.*)

Westfälische Leichtmetallwerke, Nachrodt. (*Aluminium alloys and products.*)

Holland

N.V. Nederlandsche Aluminium Maats., Utrecht. (*Aluminium alloys and products.*)

Italy

"Delta" Società Metallurgica Ligure S.p.A., Genoa. (*Aluminium alloys and products.*)

Lavorazione Leghe Leggere, Marghera (Venice). (*Aluminium alloys and products.*)

Metallurgica Feltrina, Feltre (Belluno) Works, Milan. (*Aluminium alloys and products.*)

Japan

Furukawa Aluminum Co., Ltd., Tokyo. (*Aluminium alloys and products.*)

Kobe Steel Works, Ltd., Shimonoseki. (*Aluminium alloys and products.*)

Norway

A/S Nordisk Aluminiumindustri, Oslo.
Hoyanger Works. (*Aluminium alloys.*)
Holmestrand Works. (*Aluminium alloy products.*)

Raufoss Ammunisjonsfabrikker, Raufoss. (*Aluminium alloy products.*)

Spain

Eduardo K. L. Earle, Lejona. (*Aluminium alloys and products.*)

Sweden

A/B Svenska Metallverken, Finspong. (*Aluminium alloys and products.*)

Switzerland

Aluminium S.A., Menziken. (*Aluminium alloys and products.*)

Société Anonyme pour l'Industrie de l'Aluminium, Chippis. (*Aluminium alloys and products.*)

U.S.A.

Aluminum Company of America, Pittsburgh.
Davenport Works. (*Aluminium alloys and products.*)
Lafayette Works. (*Aluminium alloys and products.*)
Massena Works. (*Aluminium alloys and products.*)

Yugoslavia

Tvornica Lakih Metala "Boris Kidric", Sibenik. (*Aluminium alloys and products.*)

MANUFACTURERS OF STEEL WIRE ROPE

The following establishments have complied with the conditions contained in P 14 of the Rules and are recognised by the Committee for the manufacture of steel wire towlines, mooring ropes, and standing rigging.

United Kingdom

Binks Bros., Ltd., London.
Bridgwater Wire Rope Works Ltd., Bridgwater.
British Ropes Ltd., Cardiff.
British Ropes Ltd., Doncaster.
British Ropes Ltd., Gateshead-on-Tyne.
British Ropes Ltd., Glasgow.
British Ropes Ltd., London.
British Ropes Ltd., Retford.
Bruntons (Musselburgh) Ltd., Musselburgh.
Catherall Ropeworks Ltd., near Sunderland.
Joseph Crawhall & Sons Ltd., Gateshead-on-Tyne.
Dawson & Usher Ltd., Sunderland.
Dixon Corbitt Ltd., Gateshead-on-Tyne.
Edge & Sons Ltd., Shifnal.
Geo. Elliott & Co., Ltd., Cardiff.
Frew Bros. Ltd., Coatbridge.
Garnock Bibby & Co., Ltd., Liverpool.
Glaholm & Robson Ltd., Sunderland.
Glover Bros. (Mossley) Ltd., near Manchester.
Hall's Barton Ropery Co., Ltd., Hull.
R. Hood Haggie & Son, Ltd., Newcastle-on-Tyne.
John I. Hopper Ltd., Thornaby-on-Tees.
Latch & Batchelor Ltd., Birmingham.
Martin, Black & Co. (Wire Ropes), Ltd., Coatbridge.
Overton Bros. Wire Ropes Ltd., Hull.
D. Morgan Rees & Sons Ltd., Cardiff.
Rylands Bros., Ltd., Warrington.
Scottish Wire Rope Co., Ltd., near Glasgow.
John Shaw Ltd., Worksop.
Sheffield Wire Rope Co., Ltd., Sheffield.
Terrells Wire Ropes Ltd., Bristol.
Archd. Thomson, Black & Co., Ltd., Port Glasgow.
Tyne Wire Rope Manufacturing Co., Ltd., South Shields.
Webster & Co., Ltd., Sunderland.
Whitecross Co., Ltd., Warrington.
Wrights' Ropes Ltd., Birmingham.

Australia

Australian Wire Rope Works Pty. Ltd.,Newcastle,N.S.W.

Austria

Joh. Pengg, Draht-und Walzwerke, Steiermark.

Belgium

Cableries & Corderies du Hainaut, S.A., Dour, near Mons.
Cableries et Fonderies de & à Montignies s/Sambre.
Corderies & Cableries Belges, et Gilly, S.A., near Charleroi.
Corderies d'Ans & Cableries de Renory, S.A., Renory.
Corderies J. B. Ligny, S.A. des Gilly.
Gonzalez Cock S.A., Lokeren.
Laurent Frères, Boussu-lez-Mons.
Le Lis, S.A., Hamme-sur-Durme.
Marcel Vermeire, Cablerie, Hamme.
Van Praet-Dansaert, Baasrode.
Vertongen-Goens S.A., Termonde.

Brazil

Cia. Industrial e Mercantil de Artefatos de Ferros, Sao Paulo.

Canada

British Ropes Canadian Factory Ltd., Vancouver.
Canada Wire & Cable Co. Ltd., Smith Falls, Ontario.
Donald Ropes & Wire Cloth Ltd., Hamilton, Ontario.

Denmark

Jacob Holm & Sønners Fabriker, A/B., Copenhagen.
Randers Rebslaaeri A/S., Randers.

Finland

Oy Teräsköysi, Helsinki.

France

Laminoirs-Tréfileries-Cableries de Lens, Lens.
Société des Aciéries & Tréfileries de Neuves-Maisons, Chatillon, Sainte-Colombe-sur-Seine, (Cote d'Or).
Saint-Frères, S/A, Saint-Ouen, Somme.
Tréfilerie et Cablerie Julien Wurth et Cie., Reichshoffen.
Tréfileries et Laminoirs du Havre.

Germany

Berkenhoff & Drebes A.G., Asslarer Hutte.
J. Bertram K.G. Drahtseilwerk, Soest.
Braucke, Adolf vom. A.G., Ihmerterbach.
Bremer Draht-und Seilindustrie G.m.b.H., Bremen-Hemelingen.
Dortmunder Drahtseilwerke G.m.b.H., Dortmund.
Drahtseilerei Gustav Kocks, Mülheim (Ruhr)—Broich.
Drahtseilwerke G.m.b.H., Bremerhaven.

Germany—*continued*

Drahtseilwerke Hugo Wohlfahrt, Neheim/Ruhr.
Felten & Guilleaume, Koln-Mulheim.
Gempt, J. H., Lengerich/Westf.
Hamburger Drahtseilerei G.m.b.H., Bad Oldesloe.
Hüttenwerk Oberhausen A.G. Werk Gelsenkirchen vorm. Boecker & Comp.
Klockner - Werke A.G. Dusseldorfer Drahtindustrie, Dusseldorf.
Norddeutsches Drahtseilwerk, A. Brinkmann, Syke.
Seilwerke Heinrich Puth K.G., Blankenstein, Ruhr.
J. & W. Vornbaumen K.G., Iburg.
Westdeutsche Seilindustrie Paul Stoessel, Osterrath b/Dusseldorf.
Westfalische Drahtindustrie, Hamm.
Westfalische Union A.G., Lippstadt.
Westfalische Union A.G. fur Eisen und Drahtindustrie Drahtseilwerk Oesede.
Wolf, Gustav, Gutersloh.

Holland

Staaldraadkabel & Herculestouwfabriek J.C. den Haan, Gorinchem.
Vereenigde Touwfabrieken, Leiderdorp.

India

National Rolling & Steel Ropes Ltd., Calcutta.
J. K. Steel, Ltd. Calcutta.

Italy

Acciaierie Ferriere Lombarde Falck, Sesto San Giovanni.
Giuseppe & Fratello Redaelli S.p.A.,—Gardone val Trompia (Brescia), Brescia.
"Ilva" Alti Forni e Acciaierie d'Italia, Torre Annunziata.
Industrie Metallurgiche Piemontesi, Susa.
Ing. Guido Scolari (Soc., Acc., Semp.), Milan.
Stabilimenti G. Fornara & Co., Turin.

Japan

Asahi Wire Rope Manufacturing Co. Ltd., Osaka.
Daido Wire Rope Mfg. Co., Ltd., Osaka.
Dainichi Seiko Co., Ltd., Sakoshi.
Kasuga Seiko K.K., Osaka.
Kawasaki Steel Corporation, Chiba Iron and Steel Works, Chiba City.
Kokoku Iron & Steel Wire Mfg. Co. Ltd., Niigata.
Kokoku Iron & Steel Wire Mfg. Co. Ltd., Osaka.
Kokoku Iron & Steel Wire Mfg. Co. Ltd., Tokyo.
Nippon Steel Wire & Wire Rope Co. Ltd., Osaka.
Nishida Wire Rope Mfg. Co. Ltd., Osaka.

Japan—*continued*

Sensyu Seiko Co. Ltd., Kaizuka.
Shinko Kosen Kosaku Co. Ltd., Amagasaki.
Showa Wire Rope Mfg. Co. Ltd., Osaka.
Tatsumi Rope Mfg. Co. Ltd., Osaka.
Teikoku Sangyo Kabushiki Kaisha, Osaka.
Tokyo Seiko Kaisha, Kokura.
Tokyo Seiko Kaisha, Tokyo.
Toyo Wire Rope Manufacturing Co. Ltd., Osaka.

Norway

Mandal Stal A/S, Mandal.
Norsk Staaltaugfabrik, Trondheim.
Tonsberg Reperbane A/S., Tonsberg.

Poland

Fabryka Lin i Drutu, Bytom Karp.
Sosnowiecka Fabryka Lin i Drutu, Sosnowiec.

Portugal

Cordoaria Lisbonense, Lisbon.
Quintas and Quintas, Povoa do Varzim.
Rodrigues d'Oliveira, M, Sa & Fos, Ltda., Oporto.

South Africa

African Wire Ropes Ltd.
(Rand Ropes Ltd., Germiston).
(Haggie, Son & Love (1936) Ltd. Cleveland).

Spain

"Nueva Montana Quijano", S.A., Santander.
Trenzas y Cables de Acero S.A., Barcelona.

Sweden

Blombacka A/B., Lindfors.
Fagersta Bruks A/B., Fagersta.
Garphytte Bruks A/B., Garphyttan.
Lesjofors A/B., Lesjofors.
Spangsholms Bruks A/B., Sya.
Stallinefabriken, David Ahlquist A/B., Roslags-Nasby.
Svenska Stållinor, A/B., Varberg.

United States of America

Jones & Laughlin Steel Corporation, Muncy, Pa.
Le Tourneau Westinghouse Co., Peoria, Illinois.
The Wire Rope Corporation of America, Missouri.

Yugoslavia

Novosadska Fabrika Kabela, Novi Sad.

PROVING ESTABLISHMENTS

The following proving establishments are recognised by the Committee of Lloyd's Register for the testing of anchors and chains while licensed by the Ministry of Transport for that purpose.

Principal Superintendent: Mr. H. Murphy. (*Stationed at Netherton.*)

	Superintendents
Netherton (near Dudley)—Lloyd's Proving House	Mr. H. Murphy
Low Walker-on-Tyne—Lloyd's Proving House	Mr. R. J. Vogan
Glasgow—Lloyd's Proving House	Mr. S. Bolton
Cardiff—Lloyd's Proving House	Mr. F. W. Dovey
Cradley Heath—Lloyd's Proving House	Mr. H. Phillips

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The following machines have been recognised by the Committee for the testing of anchors and chain cables except for anchors and chain cables supplied to ships of United Kingdom registry building in the United Kingdom or manufactured in the United Kingdom for British ships building abroad, which are to be tested at a licensed Proving House in the United Kingdom.

Australia

Falkiner Chains Pty. Ltd., South Brisbane, Queensland (for testing chain cables up to 100 tons).

Austria

Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl, Carinthia.

Belgium

Adh. Demanet, Gosselies (for testing chains up to 260 tons).

Beliard, Murdoch & Co., Antwerp (for testing anchors and chain cables up to 100 tons).

Mercantile Marine Engineering & Graving Dock Co., Antwerp.

Société Anonyme des Anciens Etablissements Wattelar-Francq, Jumet.

Usines et Acieries Allard S.A. Mont-sur-Marchienne (for testing anchors only.)

Canada

Canada Chain & Forge Co., Ltd., Granville Island, Vancouver, B.C.

Dominion Chain Co., Ltd., Niagara Falls, Ontario.

Czechoslovakia

Trinecké železárny, Velké rijnové Socialistické revoluce, narodni podnik, Retezárna Mala Morávka. (Trinec Iron Works Great Socialistic October Revolution National Corporation, Chain Works Mala Moravka).

Denmark

Orlogsværftet, Holmen, Copenhagen.

Finland

Fiskars A.B., Loimaa.

Wärtsilä-Koncernen A/B., Dalsbruks Järnverk, Helsingfors (for testing chain cables up to 250 tons).

France

Carlier et Cie., St. Amand-les-Eaux (Nord).

Davaine, Fils et Cie., St. Amand-les-Eaux (Nord) (for testing chain cables up to 132 tons).

Ets. Marit, St. Amand-les-Eaux, (Nord).

Etablissement Sirot-Mestreit, St. Amand-les-Eaux (Nord).

Fonderies Meridionales, Marseilles (for testing anchors only).

France—*continued*

Forges Nationales de la Chaussade à Guérigny, Nièvre (for testing chain cables up to 300 tons).

Paoli, J., & Co., Marseilles (for testing chain cables up to 200 tons).

Société Anonyme des Chaineries de St. Amand-les-Eaux, Etablissements Dorémieux Fils & Cie., St. Amand-les-Eaux (Nord).

Société des Forges des Fresnes, Fresnes-sur-Escaut (Nord) (for testing chain cables up to 150 tons).

Veille, A., & Co., Le Havre.

Germany

Dortmund-Hoerder Hüttenunion A.G., Dortmund Works, Dortmund (for testing anchors only).

Dortmunder Kettenfabrik Bernhard Mester, Wetterstr. 10, Dortmund.

Fröndenberger Kettenfabrik, Heinrich Prünte, Frondenberg-Ruhr (for testing chain cables up to 120 tons).

Hansa Kettenfabrik Haunschild & Co., Dortmund.

Howaldtswerke A.G., Hamburg.

Joto-Werk Josef Topp, Kettenfabrik, Warmen (Ruhr).

Kettenfabrik Kalthof, August Thiele; and August Thiele G.m.b.H., Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr.

Kettenwerke Schlieper, Grune, Westphalia.

Mannheimer Ankerfabrik u. Hammerwerk Gdbr. Heuss, Mannheim-Industriehafen (Ruhr).

Stülcken, H. C., Sohn, Schiffswerft und Maschinenfabrik, Hamburg.

Theile, J. D., Schwerte-Ruhr.

Holland

Koninklijke Nederlandsche Grofsmederij, Leiden.

N.V. Anker-& Kettingfabriek "Schiedam" (*Managing Director:* P. Th. Verhoeff), Schiedam.

Hong Kong

The Taikoo Dockyard & Engineering Co. of Hong Kong Ltd.

Italy

Acciaieria e Ferriera del Caleotto S.p.A., Lecco.

Acciaierie Weissenfels, Catenificio, Fusine di Valromana, Udine (for the testing of small chains only).

Crucible Vanzetti S.p.A., Acciaierie, Milan (for testing anchors only).

Officine Meccaniche & Fonderie, Napoletane, Naples (for testing anchors only up to 60 tons).

Japan

Hamanaka Chain Manufacturing Co., Ltd., Himeji.

Japan Mechanical Chain Manufacturing Co., Ltd., Osaka.

Komatsu Manufacturing Co., Ltd., Komatsu.

Komatsu Manufacturing Co., Ltd., Osaka Plant, Hirakata.

Koyo Chain Manufacturing Co., Ltd., Osaka.

Onomichi Anchor Manufacturing Co., Ltd., Onomichi (*for testing anchors only*).

Osaka Chain & Machinery Manufacturing Co., Ltd., Kaizuka Works, Osaka.

Tokyo Chain Works Co., Ltd., Tokyo.

Tokyo Steel Casting Co., Ltd., Tokyo.

Norway

A/S Kjættingfabriken, Helle (for testing chain cables up to 30 tons).

Norsk Kjettingindustri A/S, Mandal.

Spain

Cadenas y Forjádos, S.A., J. M. Olavarri, Bilbao. *Works:* Lejona, Bilbao.

Don Ciriaco Rodriguez Dorado, Barcelona (for testing chain cables up to 30 tons).

Forjas de San Martin de Pedro Framis, Barcelona (for testing chains up to 16 tons).

Hijos di Vicinay, S. en C., Ochandiano, Vizcaya.

Sweden

Gunnebo Bruks Aktiebolag, Gunnebobuck, Västervik (for testing chains up to 20 tons).

Jarnbirger A/B, Orsa.

Ljusne Woxna Aktiebolag, Ljusne.

Ramnäs Bruks Aktiebolag, Ramnäs.

Statens Provningsanstalt (Government Establishment), Stockholm.

United Kingdom

Brown, Lenox & Co., Ltd., Pontypridd, Monmouthshire.

North British Electric Welding Co., Ltd., Coatbridge, Lanarkshire.

Taylor, Samuel, & Sons (Brierley Hill) Ltd., Brierley Hill, Staffs.

United States

American Anchor & Chain Corporation, Fieldsboro, N.J.

American Chain Co., Braddock, near Pittsburgh, Pa.; and York, Pa. (for testing chains up to 22 tons).

United States—*continued*

Baldt Anchor, Chain and Forge Division of the Boston Metals Co., Chester, Pa.
Bellingham Chain & Forge Co., South Bellingham, Wash.
Buckeye Steel Castings Co., Columbus, O. (for breaking tests on chain cables only).
General Steel Castings Corporation, Eddystone, Pa. (for testing anchors only).
Johnson-Farmer Chain Division of the Boston Metals Co., Lebanon, Pa.
McKay Company, McKees Rocks, near Pittsburgh, Pa.
National Erie Co., Erie, Pa. (for testing anchors only).

United States—*continued*

National Malleable and Steel Castings Co., Sharon, Pa.
Portland Chain Manufacturing Co., Portland, Or.
Republic Steel Corporation, Round Chain Division.
Broadway & Chaincraft Roads, Cleveland, O.
6921, East Marginal Way, Seattle 8, Wash.
196, Freeway, So. San Francisco, Cal.
Taylor, S. G., Chain Company, Hammond, Indiana.

Yugoslavia

Poduzece "Uljanik," Pula (for loads above 20 tons).
Tovarna Verig, Lesce pri Bledu (for testing chain cables only).

N.B.—Ships supplied with anchors and chain cables tested at any of the establishments in the foregoing lists will have the notation of LACP in the Appendix to the Register Book, provided that in the case of machines other than at licensed Proving Houses in the U.K., the tests are carried out under the supervision of a Surveyor to the Society.

ELECTRICALLY WELDED STEEL CHAIN CABLES

and

CAST STEEL CHAIN CABLES

The following establishments have complied with the requirements for manufacture of electrically welded and cast steel chain cables and have been recognised by the Committee:—

GRADE I *Electrically welded chain cables of mild steel having a tensile breaking strength of 20 to 26 tons per sq. inch.*

GRADE II *Electrically welded chain cables of mild steel having a tensile breaking strength of 26 to 32 tons per sq. inch.*

GRADE III *Electrically welded special steel or cast steel, having a tensile breaking strength of 32 to 40 tons per sq. inch.*

NOTE: Before acceptance on classed ships chain cables must be tested on a chain cable testing machine recognised by the Society.

ELECTRICALLY WELDED STEEL CHAIN CABLES

FIRM	GRADE & TRADE NAME (IF ANY)	MAXIMUM DIAMETER	SURVEYING DISTRICT
United Kingdom			
Beal & Son (Cable Makers) Ltd., Cardiff.	I, II & III	4 ins.	Cardiff
Bradney Chain & Engineering Co., Ltd., Cradley Heath.	II (Short link)	$\frac{1}{2}$ in.	Birmingham
British Steel Chain Co. Ltd., Old Hill, Staffs.	I, II & III	$1\frac{13}{16}$ ins.	Birmingham
Brown, Lenox & Co. Ltd., Pontypridd.	I, II & III	4 ins.	Cardiff
Chain Developments Ltd., (N. Hingley & Co. Ltd.), West Bromwich.	I & II	$1\frac{1}{4}$ ins.	Birmingham
Griffin-Woodhouse Chain Cables Ltd., Cradley Heath, Staffs.	III	$2\frac{3}{16}$ ins.	Birmingham
North British Electric Welding Co. Ltd., Whifflet, Coatbridge, Lanarkshire.	I, II & III (One weld per link)	$4\frac{1}{8}$ ins.	Glasgow
	I, II & III (Two welds per link) (Floryt & Rytflo)	$3\frac{9}{16}$ ins.	
Parsons Chain Co. Ltd., Stourport-on-Severn.	I, II & III (Short link)	$1\frac{1}{4}$ ins.	Birmingham
Taylor, Samuel, & Sons (Brierley Hill) Ltd., Brierley Hill, Staffs.	I & II	$4\frac{1}{8}$ ins.	Birmingham
	III (Tayco)	$4\frac{1}{8}$ ins.	
Watson & Maclean Ltd., Glasgow.	III (Short link)	$\frac{7}{8}$ in.	Glasgow
Wheway, Job, & Sons Ltd., Birchills Hame & Chain Works, Walsall.	I	$\frac{7}{8}$ in.	Birmingham
	II (Short link)	$\frac{11}{16}$ in.	
Wood, Henry, & Co. Ltd., Saltney, Nr. Chester.	I & II	$\frac{11}{16}$ in.	Liverpool

Firm	Grade & Trade Name (if any)	Maximum Diameter	Surveying District
Australia			
Falkiner Chains Pty. Ltd., South Brisbane.	I	$2\frac{5}{16}$ ins.	Brisbane
	III (Famac)	2 ins.	
Austria			
Ferdinand Freiherr v. Helldorff & Otto Rothart Kettenwerk Brückl, Brückl.	I (Short link)	26 mm.	Vienna
Belgium			
Adh-Demanet, Gosselies.	I, II & III	76 mm.	Antwerp
Czechoslovakia			
Třinecké Železárny Velke Řijnové Socialistické Revoluce, Národni Podnik, Řetězárna Malá Morávka (Trinec Iron Works Great Socialistic October Revolution National Corporation, Chain Works Malá Morávka).	I & II	46 mm.	Vienna
Finland			
Fiskars A.B., Loimaa.	I	36 mm.	Åbo
Wartsilä-Koncernen A.B., Dalsbruks Järnverk, Dalsbruk.	I, II & III	64 mm.	Åbo
France			
M. Carlier & Cie., St.-Amand-les-Eaux, Nord.	I & II	30 mm.	Valenciennes
Davaine Fils et Cie., St.-Amand-les-Eaux, Nord.	I & II	30 mm.	Valenciennes
Forges Nationales de la Chaussade, Guerigny.	III	80 mm.	Marseilles
Manufacture de Chaines et Ancres de Saint-Amand, St.-Amand-les-Eaux, Nord.			
Usine A, Ets Sirot Mestreit	I, II & III	80 mm.	Valenciennes
Usine B, Ets Dorémieux	I & II	35 mm.	Valenciennes
Etablissements Marit, Saint-Amand-les-Eaux, Nord.	I & II	44 mm.	Valenciennes
Ste. des Forges de Fresnes, Fresnes sur Escaut, Nord.	I & II	65 mm.	Valenciennes
	III	60 mm.	
A. Veille et Cie., Le Havre.	I, II & III	100 mm.	Havre
	I, II & III (Monobloc)	91 mm.	
Germany			
Dortmunder Kettenfabrik B. Mester, Dortmund.	I & III	69 mm.	Dortmund
Hansa-Kettenfabrik Haunschild & Co., Dortmund.	I	90 mm.	Dortmund
	III	75 mm.	
Joto-werk, Josef Topp Kettenfabrik, Warmen (Ruhr).	I & II	68 mm.	Dortmund
	III	62 mm.	

Firm	Grade & Trade Name (if any)	Maximum Diameter	Surveying District
Germany—*continued*			
Kettenfabrik Kalthof, August Thiele; August Thiele G.m.b.H. Fabrik für Ketten und Kettenforderer, Kalthof, near Schwerte-Ruhr.	I, II & III	105 mm.	Dortmund
Kettenwerke Schlieper, Grune-Westfalen.	I, II & III	110 mm.	Dortmund
Theile, J. D., Schwerte-Ruhr.	I, II & III	92 mm.	Dortmund
Holland			
Anker-En Kettingfabriek "Schiedam", Schiedam.	III	78 mm.	Rotterdam
Koninklijke Nederlandsche Grofsmederij, Leiden.	I, II & III (Ego)	85 mm.	Rotterdam
	I & II (Eldam)	75 mm.	
Italy			
Acciaieria e Ferriera del Caleotto, Lecco.	I, II & III	80 mm.	Milan
Japan			
Hamanaka Chain Manufacturing Co. Ltd., Himeji.	III	88 mm.	Kobe
Japan Mechanical Chain Manufacturing Co. Ltd., Osaka.	III (Kikai)	64 mm.	Kobe
	I, II & III (Flash welded)	58 mm.	
Komatsu Manufacturing Co. Ltd., Osaka.	III	97 mm.	Kobe
Koyo Chain Mfg. Co., Ltd., Osaka.	I, II & III	42 mm.	Kobe
Osaka Chain & Machinery Mfg. Co., Ltd., Osaka.	III	76 mm.	Kobe
Tokyo Chain Works Co. Ltd., Tokyo.	I, II & III	76 mm.	Yokohama
Norway			
Kjettingfabriken, A/S, Helle.	I (Short link)	19 mm.	Oslo
Norsk Kjettingindustri A/S., Mandal.	I (Short link)	25 mm.	Oslo
	I (Stud link)	19 mm.	
South Africa			
McKinnon Chain (South Africa) Ltd., Vereeniging	I (Short link)	$\frac{3}{4}$ in.	Vereeniging
Spain			
Cadenas y Forjados, Bilbao.	I, II & III	73 mm.	Bilbao
Vicinay S.A., Deusto.	I, II & III	57 mm.	Bilbao

Firm	Grade & Trade Name (if any)	Maximum Diameter	Surveying District
Sweden			
Gunnebo Bruks Aktiebolag, Gunnebobruk.	I & II	16 mm.	Stockholm
Jarnbirger A/B, Orsa.	I, II & III	55 mm.	Stockholm
Ljusne-Woxna Aktiebolag, Kattingfabriken, Ljusne.	I, II & III	92 mm.	Stockholm
Ramnäs Bruks Aktiebolag, Ramnäs.	I, II & III	98 mm.	Stockholm
United States of America			
Baldt Anchor, Chain & Forge Division, Chester, Pennsylvania.	III (Weld in alternate links)	$\frac{5}{8}$ in.	Philadelphia
	III (Flash welded)	$4\frac{1}{4}$ ins.	
Yugoslavia			
Tovarna Verig, Lesce.	I, II & III	57 mm.	Rijeka

CAST STEEL CHAIN CABLES

United Kingdom			
Brown, Lenox & Co. Ltd., Pontypridd.	III	3 ins.	Cardiff
Japan			
Komatsu Manufacturing Co. Ltd., Komatsu.	III	89 mm.	Kobe
Osaka Chain & Machinery Manufacturing Co. Ltd. (Kaizuka Works), Osaka.	III	89 mm.	Kobe
Tokyo Steel Casting Co. Ltd., Tokyo.	III	89 mm.	Yokohama
United States of America			
The National Malleable & Steel Casting Co., Sharon, Pennsylvania.	III (Naco)	$3\frac{1}{2}$ ins.	Pittsburgh

By order of the Committee,

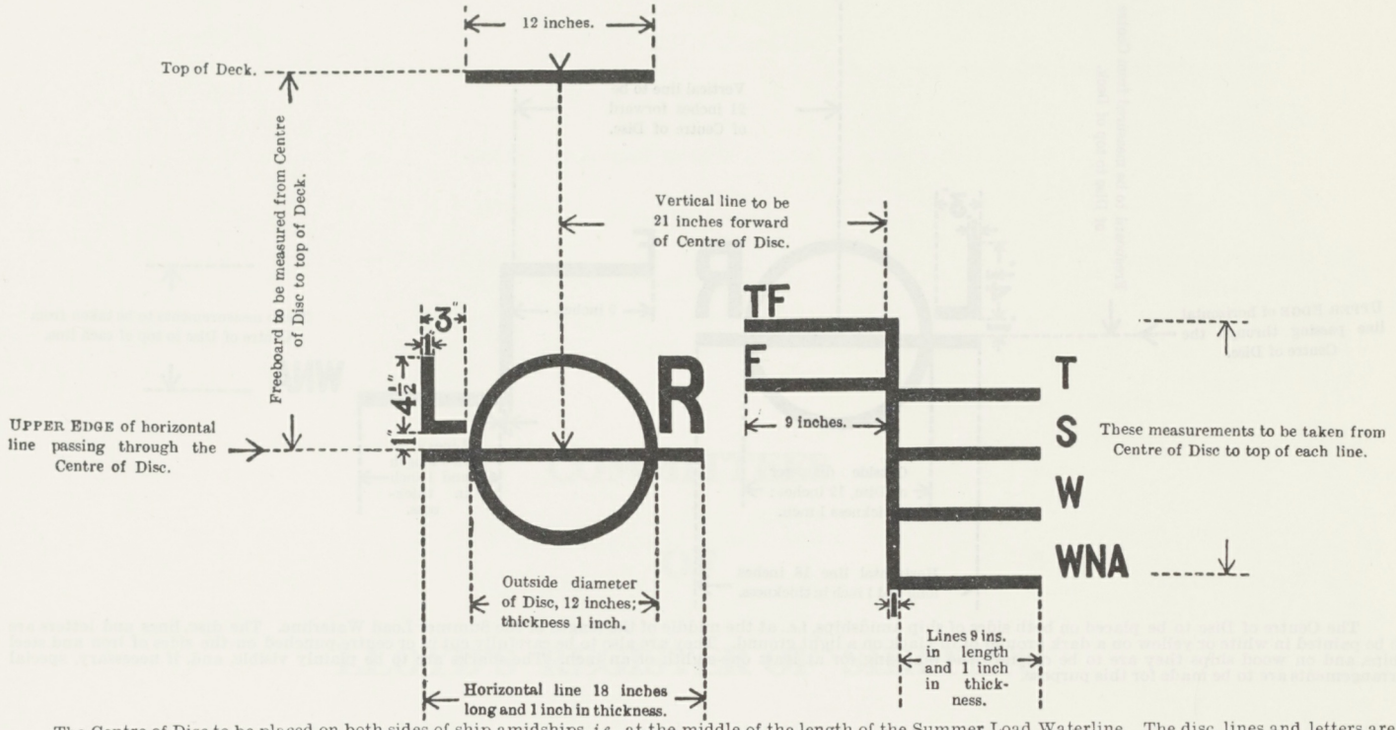
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ASSIGNMENT OF FREEBOARD

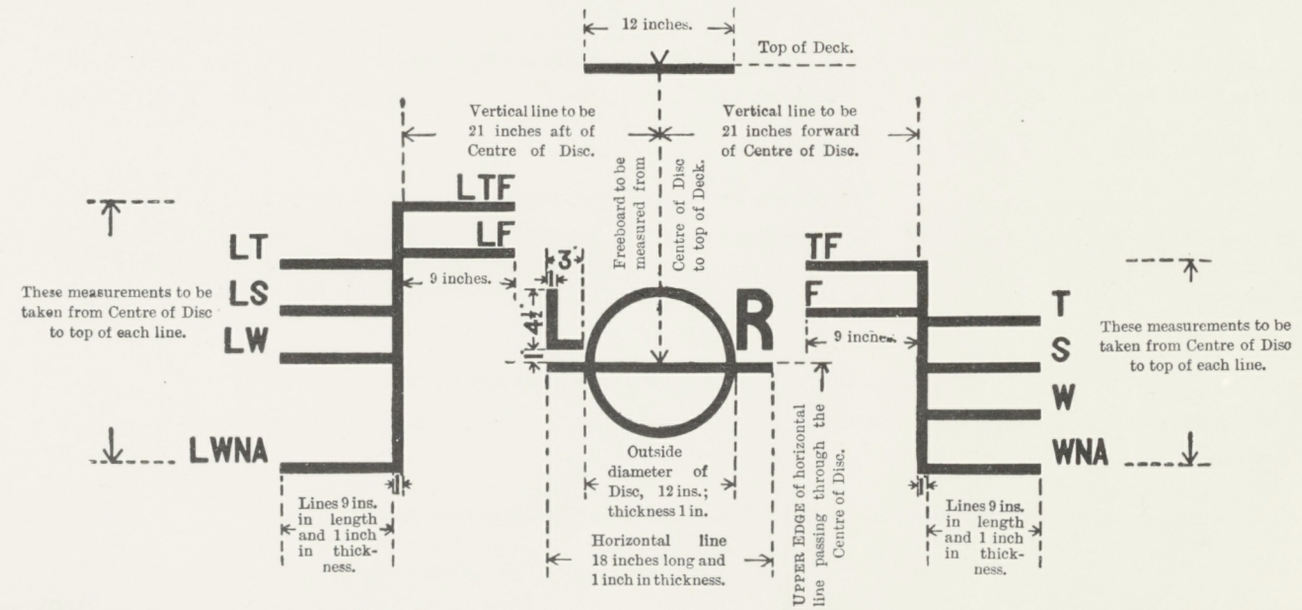
The Committee of Lloyd's Register are empowered to assign freeboards to British ships and to ships registered in other countries. Forms of application for the assignment of freeboard can be obtained from the London Office, or other offices of the Society.

FREEBOARD MARKING FOR STEAM SHIPS AND MOTOR SHIPS



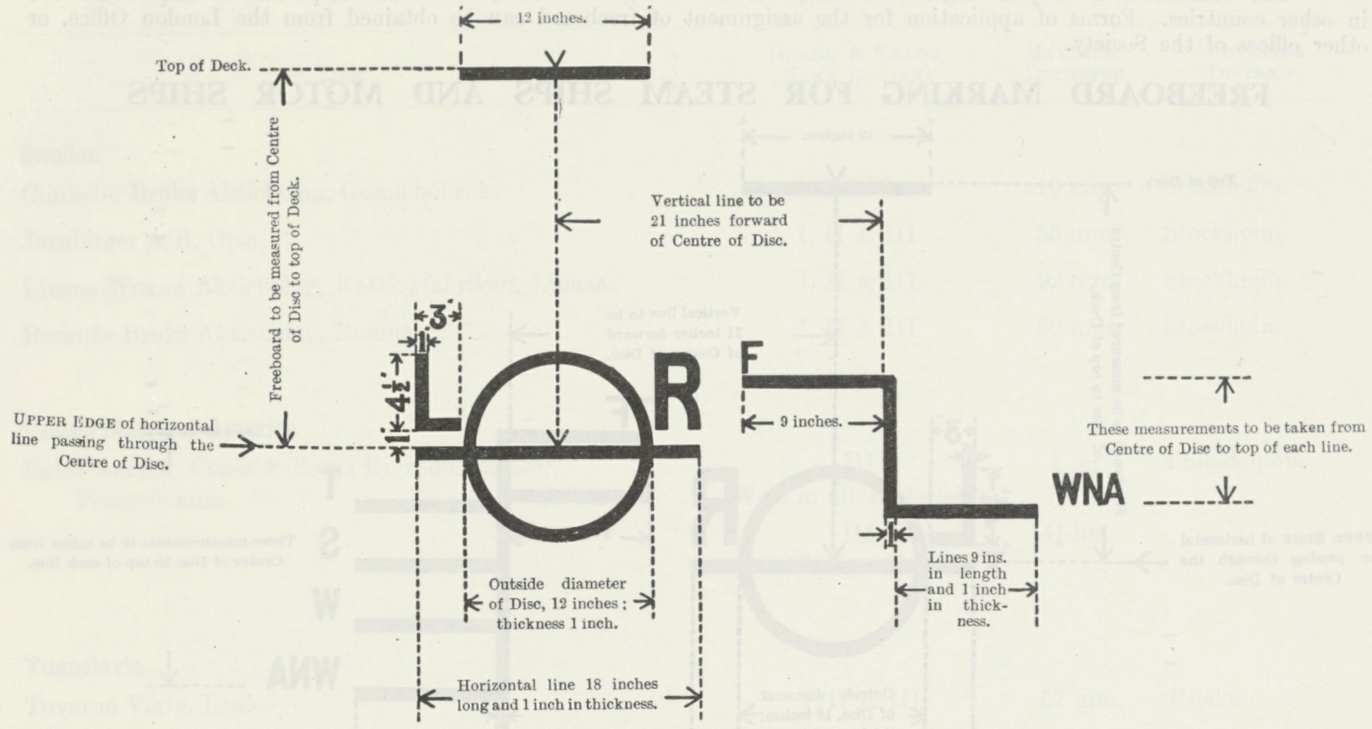
The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose. Ships over 330 feet in length are not required to be marked with the W.N.A. line.

FREEBOARD MARKING FOR SHIPS CARRYING TIMBER DECK CARGOES



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for the purpose. Ships over 330 feet in length are not required to be marked with the W.N.A. line.

FREEBOARD MARKING FOR SAILING SHIPS



The Centre of Disc to be placed on both sides of ship amidships, *i.e.*, at the middle of the length of the Summer Load Waterline. The disc, lines and letters are to be painted in white or yellow on a dark ground or in black on a light ground. They are also to be carefully cut in or centre-punched on the sides of iron and steel ships, and on wood ships they are to be cut into the planking for at least one-eighth of an inch. The marks are to be plainly visible, and, if necessary, special arrangements are to be made for this purpose.

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LLOYD'S REGISTER OF SHIPPING

November, 1961

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Office: Marine Building, Akti Miaouli and 1 Skouzé St., Piræus
Telephone Nos. 40-664 and 473-818 Telegrams: Register, Piræus

Ship and Engineer Surveyors ... ... E. F. Reid
A. Jackson

Ship Surveyor ... ... C. A. Philippou, B.Sc.

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Office: Westblaak 32; Post Office Box No. 701, Rotterdam
Telephone No. 135355 (3 lines) Telegrams: Lloydreg, Rotterdam

Ship Surveyors

W. B. Scheelings
Ir. P. J. N. Jiskoot
A. Zur-Muhlen
G. J. de Jong
G. Kamps
K. van Duffelen
A. Schreuder
L. O. Jonker
H. T. G. Steenstra
C. N. Kruiten
M. B. van der Moezel
M. Boudesteyn
D. J. Bongertman

Ship and Engineer Surveyors ... ... J. F. Vrouwes
A. van Hasselt
A. C. van Bezuije
W. Boone

Engineer Surveyors

E. M. Dudock
J. Baart
H. A. Schippers
J. G. F. Warris
H. Delwel
D. Kampman
P. J. Stuy
J. van Son

Electrical Engineer Surveyors ... ... H. van der Sluis
F. Nooteboom

AMSTERDAM, *with all ports north of the line Scheveningen-Leiden-Utrecht-Arnhem but excluding those ports; also the Island of Texel*

Office: Prins Hendrikkade 159, Amsterdam
Telephone Nos. 24-38-95, 6-26-25 Telegrams: Lloydsreg, Amsterdam

Ship Surveyors

L. H. Wehrmeijer
I. G. ten Sijthoff
E. D. Pronker
L. Barendregt

Ship and Engineer Surveyors ... ... A. C. Buijze
J. A. van Lare

Engineer Surveyors

H. P. Abel
D. van Couwelaar
J. C. Karelse
L. Schat
F. J. Leijgraaff

GRONINGEN, *with the north-eastern provinces of Groningen and Friesland including the Island of Terschelling and south as far as the port of Hasselt*

Office: Rijksstraatweg 336, Haren-Groningen
Telephone No. 44926 Telegrams: Lloyds Register, Groningen

Ship Surveyors ... ... M. J. de Bilt
A. J. Kraayenbrink

Engineer Surveyors ... ... C. P. Molenaar
G. Bons

ICELAND

REYKJAVIK

Office: Hamarshusinu, Tryggvagötu, Reykjavik
Telephone Nos. 5420 (Office); 7586 (Residence) Telegrams: Jessen, Grenimel 6, Reykjavik

Ship and Engineer Surveyor... ... ... *V. R. Jessen

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Telephone Nos. 290–741 and 290–742 Telegrams: Surveyors, Genoa

Senior Engineer Surveyor for Italy... ... Dott. Ing. A. Grasselli

Ship Surveyors

E. Little
E. Winter
A. Tilson, B.Sc.
J. B. Dunbar
Dott. Ing. E. V. Villa

Ship and Engineer Surveyors ... ... A. Ansaldo
S. Dinnen

Engineer Surveyors

S. Follo
G. Vigo
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Electrical Engineer Surveyor ... ... S. Gasperini

Metallurgical Surveyor ... ... G. Maggi

Sub-Office at **LA SPEZIA,** *with Levanto, Muggiano and ports south to, but excluding, Viareggio*

Office: Via G. Constantini, 30, La Spezia
Telephone No. 21.948 Telegrams: Surveyors, La Spezia

Ship Surveyor ... ... Dott. Ing. G. Montani

Ship and Engineer Surveyor... ... ... P. Cesari

Engineer Surveyor ... ... F. Battagli

LEGHORN, *with all ports extending from Viareggio to Civitavecchia inclusive*

Office: 132 Via Goito, Leghorn
Telephone No. 31.115 Telegrams: Gandolfo, Goito 132, Leghorn

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Office: Via Turati, 8, Milan
Telephone No. 652–938 Telegrams: Surveyors, Milan

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D. Cecchi
D. Lamuraglia
Dott. Ing. R. O. Winternitz
(Resident at the Latina Site)
G. Levi
A. Bertoli

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Office: Piazza Municipio 84 (3rd floor), Naples
Telephone No. 23–714 Telegrams: Surveyors, Naples

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Engineer Surveyor ... ... C. Starc
Ship Surveyor ... ... Dott. Ing. M. V. Pollio

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Office: Via Duca Della Verdura 83/5°, Palermo
Telephone No. 264.667 Telegrams: Surveyors, Palermo

Ship and Engineer Surveyors ... ... E. Grieves
W. J. G. Wilson
Ship Surveyor ... ... Dott. Ing. F. Petronio

TRIESTE, *with Monfalcone*

Office: Via Mazzini No. 9, Trieste
Telephone No. 24420 Telegrams: Register, Trieste

Ship Surveyors ... ... S. B. Lumsden
Dott. Ing. F. Suligoi
A. Parodi
Ship and Engineer Surveyors ... ... J. J. Wilson, M.B.E.
J. B. Baillie
Engineer Surveyor ... ... Dott. Ing. E. Speri

Sub-Office at **VENICE (Mestre),** *with surrounding district including Bolzano*

Office: Corso del Popolo, 179, Mestre (Venice)
Telephone No. Venice 52903 Telegrams: Surveyors, Mestre

Ship and Engineer Surveyor... ... ... Dott. Ing. S. Verdarelli
Engineer Surveyor ... ... C. M. Diviacco

MALTA

MALTA

Office: 5a Las Caris Buildings, Las Caris Wharf, Valetta
Telephone No. Central 26536 Telegrams: Register, Malta

Ship and Engineer Surveyor... ... ... W. J. Hipwell

NORWAY

SENIOR SURVEYOR FOR NORWAY ... ... D. T. GRANT (Resident at Oslo)

BERGEN, *with a district extending from Farsund to Kristiansund inclusive*

Office: 1, Slottsgate, Bergen
Telephone No. 15634 (Private No. 98547) Telegrams: Surveyor, Bergen

Ship and Engineer Surveyor... ... ... L. O. Nordaas
Engineer Surveyor ... ... K. Olsen

KONGSBERG

Inspector of Forgings ... ... *K. J. Hansen

OSLO, *with a district extending from Mandal to Halden inclusive and the port of Trondheim*

Office: Tollbodgaten 27, Oslo
Telephone No. 424932 Telegrams: Surveyor, Oslo

Ship Surveyor ... ... D. T. Grant
Ship and Engineer Surveyor... ... ... L. Tveit
Engineer Surveyors ... ... S. K. Person
P. L. Vaheim

Sub-Office at **NARVIK,** *with a district extending to all ports north of Trondheim*

Office: L.K.A.B's. Office Building; P.O. Box 212, Narvik
Telephone No. Central 1020, line no. 192.
Engineer Surveyor ... ... A. Bankerod Jacobsen

Sub-Office at **MO I RANA**
(All correspondence should be addressed to OSLO)
Surveyor for Materials ... ... *P. Ofsdahl

POLAND

SENIOR SURVEYOR FOR POLAND ... ... E. TEE, M.B.E. (Resident at Gdansk)

GDANSK

Office: c/o C.B.K.O. No. 1, ul. Jana z Kolna 31, P.O. Box 273, Gdansk
Telephone No. 32774 Telegrams: Register, Gdansk

Ship Surveyors
Ir. R. J. C. Dobson
(Resident at Szczecin)
J. G. Lambie, B.Sc.
Dipl. Ing. M. Pycinski
A. Tyc

Engineer Surveyors
G. Manson
P. J. Beaman
N. Dienes
B. Langhamer

KATOWICE

Office: 20 ul Sokolska, Katowice
Telephone No. 337.79

Metallurgical Surveyor ... ... N. D. Tosh
Engineer Surveyor ... ... L. Weber

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Telephone No. 664131 Telegrams: Register, Lisbon

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E. A. Pickering
Engineer Surveyor ... ... E. A. Hardcastle
Ship Surveyor ... ... J. Fleming

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PRINCIPAL SURVEYOR FOR SPAIN ... ... G. J. THOMAS (Resident at Madrid)

MADRID, *with a district including Salamanca*

Office: Calle de la Princesa 29, 2° izqda, Madrid, 8
Telephone No. 2. 47–92–47 Telegrams: Register, Madrid
(*Communications should be addressed to the Principal Surveyor*)

BARCELONA, *with a district including San Feliu de Guixols to Vinaroz, also the Balearic Islands*

Office: Paseo de Colon 11, Barcelona, 2
Telephone No. 2.19601 Telegrams: Surveyors, Barcelona
Ship and Engineer Surveyors ... ... R. W. Stonehouse
J. Marina

BILBAO, *with Zaragoza, Valladolid and a district extending from Pasajes to Santander*

Office: Gran Via, 83, 1° izqda, Apartado de Correos 286, Bilbao
Telephone No. 16995 Telegrams: Register, Bilbao
Ship and Engineer Surveyors
T. O. Morris J. M. Ruiz
F. Larrucea
Engineer Surveyors ... ... J. G. Heads
D. Rennie
Metallurgical Surveyor ... ... N. B. Buck
Ship Surveyors ... ... S. C. W. Gresham
I. H. White
G. S. McIntosh

CADIZ, *with a district from Almeria to Huelva*

Office: Avenida del Generalisimo Franco, 2-1°, Cadiz
Telephone No. 14555 Telegrams: Registro, Cadiz
Ship Surveyors
T. Jaroszynski, B.Sc. G. Coggon
(*Senior Ship Surveyor for Spain*) A. I. L. Pagan
Ship and Engineer Surveyor... ... ... J. N. P. Douglas
Engineer Surveyor ... ... S. Bailey

Sub-Office at **SEVILLE**

Office: c/o Empresa Nacional Elcano, Astilleros de Sevilla, Apartado de Correos 89, Sevilla
Telephone No. 32370 & 32379 Telegrams:
Ship Surveyor ... ... H. Nutter, B.Sc.

EL FERROL, *with a district extending from El Ferrol to Vigo*

Office: General Franco, 2-4, 1° El Ferrol Del Caudillo, Ferrol
Telephone No. 3480, Ext. 214 Telegrams: Register, El Ferrol
Ship Surveyor ... ... A. M. Hopkins
Ship and Engineer Surveyor... ... ... W. Lund

GIJON, *with a district extending from Gijon to San Esteban de Pravia including La Felguera and Trubia*

Office: Edificio San Esteban, Gijon
Telephone No. 9515 Telegrams: Register, Gijon
Ship and Engineer Surveyor... ... ... J. R. P. Conolly

VALENCIA, *with a district including Castellón to Cartagena*

Office: Edificio Cofruna, Grao, Valencia
Telephone No. 23.16.39 Telegrams: Register, Valencia
Ship Surveyor ... ... A. J. Smith
Engineer Surveyor ... ... B. B. Maddocks

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PRINCIPAL SURVEYOR FOR SWEDEN ... ... C. J. G. JENSEN, B.Sc. (Resident at Gothenburg)

GOTHENBURG, *with a district extending from Strömstad to Falkenberg inclusive, also the port of Kalmar on the East coast*

Office: Järntorget, 3, Gothenburg, SV.
Telephone No. 124230 Telegrams: Surveyor, Gothenburg
Ship Surveyors
B. Grauers, Civ. Ing. S. Janzén, Civ. Ing.
N. Flensburg, Civ. Ing. L. Dohm-Hansen
B. Roslund T. A. Lamplough, B.Sc.
L. Todd Y. D. Malmkvist, Civ. Ing.
K. O. L. Nilsson, Civ. Ing.
Assistant Ship Surveyor ... ... A. H. Marklund, Civ. Ing.
Ship and Engineer Surveyors
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A. Ozols K. G. Friman
Engineer Surveyors
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Electrical Engineer Surveyor ... ... J. M. Gardiner

Sub-Office at **UDDEVALLA**

Office: Kilbacksgatan 31, Uddevalla
Telephone No. 30058
Ship and Engineer Surveyors ... ... C. O. Scotting
L. E. Larson
Ship Surveyor ... ... L. Brewer

HELSINGBORG, *with a district extending from Halmstad to Landskrona, inclusive*

Office: Bryggaregatan 35a, Helsingborg
Telephone Nos. 10594 and 22130 Telegrams: Surveyor, Helsingborg
Ship and Engineer Surveyors ... ... T. Österberg
S. B. Bovin
Ship Surveyor ... ... D. J. Maclachlan
Assistant Ship Surveyor ... ... N. T. Johansson

MALMÖ, *with a district extending from Malmö to Karlskrona, inclusive*

Office: Skeppsbron 3, Malmö
Telephone Nos. 21871–21881 Telegrams: Register, Malmö
Ship and Engineer Surveyor ... ... A. O. Börring
Engineer Surveyor ... ... S. J. V. Friberg
Ship Surveyors ... ... W. R. D. Saxton
R. A. B. Kahl, Civ. Ing.

STOCKHOLM, *with all ports on the East Coast of Sweden north of Kalmar, and including the Islands of Gotland and Åland*

Office: Bellmansgatan 15, Stockholm, S Ö.

Telephone No. 44.03.40 Telegrams: Lloydsregister, Stockholm

Ship and Engineer Surveyors

V. T. Bülow
I. Lager
K. Eriksson
J. H. Clugston
L. O. Sandell

Engineer Surveyor ... ... S. O. R. Bomler

Electrical Engineer Surveyor ... ... A. Pullar (*Resident at Västerås*)

Ship Surveyors

H. O. Albertson, Civ.Ing.
S. A. D. Schierwagen, Civ.Ing.
F. Reid

Surveyor for Materials ... ... G. A. Gillberg (*Resident at Luleå*)

SWITZERLAND

WINTERTHUR

Office: Neuwiesenstrasse 3, Winterthur

Telephone No. 81122, Internal 3543/4 (Home 63785) Telegrams:

Ship and Engineer Surveyors ... ... T. D. Potts
J. C. Harrison, B.Eng.

Electrical Engineer and Engineer Surveyor ... A. Carey (*Resident at Zurich*)

TURKEY

ISTANBUL

Office: Rihtim Caddesi Arzu Han 5/6, Tophane, Istanbul

Telephone No. 441286 Telegrams: Lloydsurv, Istanbul

Ship Surveyor ... ... G. J. Boulter

Engineer Surveyor ... ... J. Wood

YUGOSLAVIA

PRINCIPAL SURVEYOR FOR YUGOSLAVIA ... ... DIPL. ING. D. STIPETIC (Resident at Split)

ADMINISTRATIVE OFFICER FOR YUGOSLAVIA ... ... G. MAJCEN, B.Sc. (Resident at Split)

SPLIT

Office: Setaliste M. Pijade 1, Split

Telephone No. 3076 Telegrams: Register, Split

Ship Surveyors ... ... J. Frize
Dipl. Ing. F. Beban

Engineer Surveyors ... ... F. B. Gray
Dipl. Ing. M. Brajnovic

Metallurgical Surveyor ... ... Dipl. Ing. S. Vukicevic

Sub-Office at **RIJEKA**

Office: Palaca Jadran, V Kat, Rijeka

Telephone No. 59–77 Telegrams: Register, Rijeka

Ship Surveyors ... ... R. N. Hunter
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Ship and Engineer Surveyors ... ... W. P. Watson
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Engineer Surveyors ... ... F. G. Burn
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AMERICA—UNITED STATES

CHIEF REPRESENTATIVE, AND PRINCIPAL SURVEYOR FOR THE UNITED STATES, PANAMA, WEST INDIES, CUBA, NETHERLANDS ANTILLES AND VENEZUELA ... W. J. ROBERTS, B.Eng. (Resident at New York)

NEW YORK, N.Y.

Office: 17, Battery Place, New York, 4
Telephone Nos. Whitehall 4–0220, 0221, 0222 & 0223 Telegrams: Nymdible, New York

Principal Engineer Surveyor at New York... R. R. Holtum
Ship Surveyors ... ... T. A. Simpson
W. F. Stoot, M.Sc.
W. E. Tuck

Ship and Engineer Surveyors
B. S. Witowski
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D. D. Dick

Engineer Surveyor ... ... V. W. Bugg
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BALTIMORE, Md.

Office: 1223–4, Munsey Building, Baltimore, 2
Telephone No. Plaza 2-2411 Telegrams: Surveyor, Baltimore

Ship Surveyor ... ... E. Flynn
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BOSTON, Mass., *with Providence, R.I., and Bath*

Office: Room 927, 131, State Street, Boston, 9
Telephone No. Hubbard 8674 Telegrams: Surveyor, Boston

Ship and Engineer Surveyor... ... ... *Thomas Barrie

CHICAGO, Ill. (*see under* CLEVELAND)

CLEVELAND, Ohio, *with Buffalo, Detroit and Chicago*

Office: 1323, The Illuminating Building, 55, Public Square, Cleveland 13, Ohio
Telephone No. Main 1–3910 Telegrams: Lloyds, Cleveland

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Metallurgical Surveyor ... ... J. M. Grove, B.Sc.
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Office: 107, Cotton Exchange Building, Galveston
Telephone No. SO 2–2832 Telegrams: Register, Galveston

Ship and Engineer Surveyor ... ... W. D. Wardle

JACKSONVILLE, Fla., *with Charleston, S.C., Savannah, Ga. and Tampa, Fla.*

Office: 1805-B, Atlantic Blvd., Jacksonville 7, Fla.
Telephone No. Ex. 8–0001 Telegrams: Register, Jacksonville

Ship and Engineer Surveyor... ... ... *K. Moller

LOS ANGELES, Calif., *with Long Beach and San Diego*

Office: 119, Anaheim Street W., Wilmington, Calif. (P.O. Box 575)
Telephone No. Terminal 4–2334 Telegrams: Lloyds, Wilmington, Calif.

Ship and Engineer Surveyor... ... ... F. A. J. Findley

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Telephone No. Franklin 4–2843 (Office); Homestead, Florida, Circle 7–5947 (Residence) Telegrams: Surveyor, Miami

Ship and Engineer Surveyor... ... ... *F. H. Hallbauer

MOBILE, Ala., *with Pensacola, Fla.*

Office: Room 1502, Merchants National Bank Building, Mobile, 11
Telephone No. 2–4882 Telegrams: Register, Mobile

Ship and Engineer Surveyor... ... ... W. Scott

NEW ORLEANS, La.

Office: Room 1016, Whitney Bank Building, New Orleans, 12, La.
Telephone No. Jackson 5–8998 Telegrams: Register, New Orleans

Ship and Engineer Surveyor... ... ... W. C. Cowin

NEWPORT NEWS, Va., *with Norfolk and Richmond, Va., and Wilmington, N.C.*

Office: C. & O. Terminal Building, Newport News (P.O. Box 558)
Telephone No. 5–1661 Telegrams: Register, Newport News

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Telephone Nos. Pennypacker 5–8764, 8765 Telegrams: Surveyors, Philadelphia

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Ship and Engineer Surveyors ... ... D. J. Archibald
E. J. P. Wray

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Office: Room 1210, Matson Building, 215, Market Street, San Francisco, 5
Telephone No. Douglas 2-0823 Telegrams: Freeboard, San Francisco

Ship and Engineer Surveyor... ... ... E. Marlborough

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Telephone No. PR 8-1930 **Telegrams:** Lloyds, Seattle

Ship and Engineer Surveyor... ... ... *H. J. Caple

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HONOLULU, *with a district covering the Hawaiian Islands*

Office: 711, N. Nimitz Highway, P.O. Box 2411, Honolulu
Telephone No. 61.022

Ship and Engineer Surveyor... ... ... *B. P. Thibadeau

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BALBOA, *with a district including all ports in the Panama Canal Zone*

Office: 218, Pacific Terminal Building, Balboa; P.O. Box 304
Telephone No. 1831 Telegrams: Register, Balboa

Ship and Engineer Surveyor... ... ... **C. H. Haman**

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KINGSTON, Jamaica

Office: Royal Mail Building, Port Royal Street, Kingston
Telephone No. 2930 Telegrams: Edwat, Jamaica

Ship and Engineer Surveyor ... ... *E. Watson

PORT OF SPAIN, Trinidad

Office: Colonial Building, 72–74, South Quay, Port of Spain, Trinidad
Telephone No. 8881 **Telegrams: Care Huggins,** Port of Spain

Ship and Engineer Surveyor... ... ... J. L. Lumsdon

NASSAU, Bahama Islands (*see* MIAMI, FLA.)

CUBA

HAVANA

Office: Oficios 152, Havana; P.O. Box 1746
Telephone No. A-3760 Telegrams: Don Wheel, Havana

Ship and Engineer Surveyor... ... ... ***A. del Moral**

NETHERLANDS ANTILLES

CURAÇAO, *including Aruba*

Office: De Castro Building, Apartment No. 3, Willemstad; P.O. Box 121, Curaçao
Telephone No. 12384 Telegrams: Register, Curaçao

Ship and Engineer Surveyor... ... ... J. C. Nobels

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SOUTH AMERICA

BUENOS AIRES, *including all ports in Argentina*

Office: Calle 25 de Mayo 158, Buenos Aires

Telephone Nos. 33–2364 and 30–2640 Telegrams: Surveyors, Buenos Aires

Ship and Engineer Surveyors

A. F. Sinclair
J. Moar
R. M. Leach
W. F. Rogerson

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Office: Quinta "JOMARO" 9° Transversal, Altamira-Caracas

Telephone No. 33.32.08 Telegrams: Marsur, Caracas

Ship and Engineer Surveyor... ... ... *Ing. J. J. Schoo

MONTEVIDEO, Uruguay, *with all Uruguayan ports from Maldonado to Paysandu*

Office: Calle Solis 1480, 1° Piso (Casilla de Correo 524), Montevideo

Telephone No. 8.55.57 Telegrams: Surveyor, Montevideo, Uruguay

Ship and Engineer Surveyor ... ... T. O. Winter

RIO DE JANEIRO, Brazil, *and Brazilian coast, except Santos*

Office: Rua da Candelaria 80, 6th Floor ; Caixa Postal 4481, Rio de Janeiro

Telephone No. 23.2523 Telegrams: Surveyor, Rio de Janeiro

Ship and Engineer Surveyors ... ... E. Howey
J. T. Thirlaway

Ship Surveyor ... ... R. S. Leishman

SANTOS, Brazil

Office: Rua Brás Cubas, 3, 9° and.-sala 19; Caixa Postal 2039 (Gonzaga), Santos

Telephone No. 2–8097 Telegrams: Surveyor, Santos

Ship and Engineer Surveyor... ... ... C. A. Davies

TALCAHUANO, Chile, *with a district extending from Constitucion in the north to Peninsula Tres Montes in the south*

Office: Casilla 615, Concepcion, Chile

Telephone No. 1925-J Telegrams: Pelloyd, Concepcion

Ship and Engineer Surveyor... ... ... *K. O. Pearson

VALPARAISO, Chile, *with a district extending from Talca in the south to Arica in the north*

Office: Calle Almirante Señoret No. 48 (Casilla 148), Valparaiso

Telephone No. 4604 Telegrams: Airdrie, Valparaiso

Ship and Engineer Surveyor... ... ... R. A. Loraine

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CANADA

PRINCIPAL SURVEYOR FOR CANADA ... ... A. R. RIDDELL (Resident at Montreal)

MONTREAL AND QUEBEC, *with a district including the Gulf and River St. Lawrence to Kingston, Ont.*

Office: Canada Steamship Lines Building, 759, Victoria Square (Room 51), Montreal, P.Q.

Telephone No. Victor 9–6386 Telegrams: Register, Montreal

Senior Ship Surveyor for Canada ... ... D. S. Forsyth

Ship Surveyors ... ... F. S. J. McKinlay
S. R. Wilson
(Resident at Quebec)
M. Merrett, B.Sc.

Ship and Engineer Surveyors

D. Halkett
(Resident at Quebec)
T. N. Ross
W. Heatlie
D. McKinnon

Engineer Surveyors ... ... A. A. Crawford
G. Patterson

HALIFAX, N.S., *with Sydney and Pictou, N.S.*

Office: 37, Furness Withy Building, Halifax

Telephone No. 423–7506 Telegrams: Lloyd, Halifax, N.S.

Ship and Engineer Surveyors ... ... L. M. Mathers
A. L. McIntosh

SAINT JOHN, N.B.

Office: Customs Building, 5th Floor, 189, Prince William Street; P.O. Box 546, St. John, N.B.

Telephone No. 3–2789 Telegrams:

Ship Surveyor ... ... K. Harrison

Ship and Engineer Surveyor ... ... A. K. McDougall

ST. JOHN'S, Newfoundland

Office: Newfoundland Provincial Government Confederation Building, Department of Fisheries, P.O. Box E-5054, St. John's

Telephone Nos. Direct Line: 94212 (Office) Telegrams: Surveyor, St. John's
90174 (Residence)
Exchange: 95011 Ext. 644

Ship and Engineer Surveyor... ... ... R. A. Harvey

TORONTO, Ont., *with a district including all ports on the Canadian side of the Great Lakes from (but not including) Kingston, Ont., to Port Arthur, Ont.*

Office: Commerce and Transportation Building, 159, Bay Street (Room 616), Toronto

Telephone No. Empire 4–8617 Telegrams: Seaworthy, Toronto

Ship and Engineer Surveyors

L. D. MacBean
(Senior Surveyor for the Toronto District)
G. Peddie
E. G. White
(Resident at St. Catharines)
F. G. H. White

Ship Surveyor ... ... T. L. Millar

Sub-Office at **PORT ARTHUR, Ont.**

Office: c/o Port Arthur Shipbuilding Co., Ltd., Port Arthur, Ont.

Ship and Engineer Surveyor... ... ... J. Macdonald

VANCOUVER AND VICTORIA, B.C., *including Vancouver Island and all ports in British Columbia*

Office: 1718, Marine Building, Vancouver 1, B.C.

Telephone No. Mutual 1–5188 Telegrams: Registrar, Vancouver

Ship and Engineer Surveyors

J. A. Stewart
(Senior Surveyor for the Vancouver District)
T. Taylor

AFRICA

UNITED ARAB REPUBLIC

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S. E. I. Fawzi, B.Sc.

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ADEN

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BAHREIN

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Office: P.O. Box 109, Visakhapatnam Port, Visakhapatnam, S. India
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Telephone No. Telegrams: Register, Djakarta

(*Communications should be addressed to the Senior Surveyor*)

SOURABAYA

Office: Djalan Raya Darmo 130, Sourabaya, Indonesia
Telephone No. Darmo No. 6147 Telegrams: Surveyor, Sourabaya

Engineer Surveyor ... ... A. Ross

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Telephone No. Telegrams: Register, Khorramshahr

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Telegrams: Register, Whyalla, South Australia

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SENIOR SURVEYOR FOR NEW ZEALAND ... ... F. E. TURPIE (Resident at Wellington)

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